

> **THE SCIENCE
OF DREAMS**
Random thoughts or mental superpower?

> **REINVENTING
THE WHEEL**
Our oldest tech needs a makeover

AUSTRALIAN

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SIGNALS FROM SPACE

Have we already
recorded an alien message...
but just not know it yet?



Special Report!



THE MISSING LINK

What (or who)
separates us from
the animals?

< CURE FOR OBESITY

Using science,
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< PLAYING WITH FIRE

Could the Large
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destroy the world?



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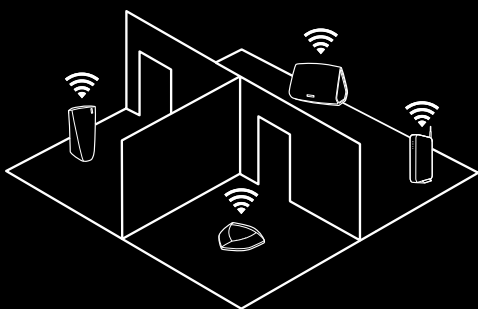
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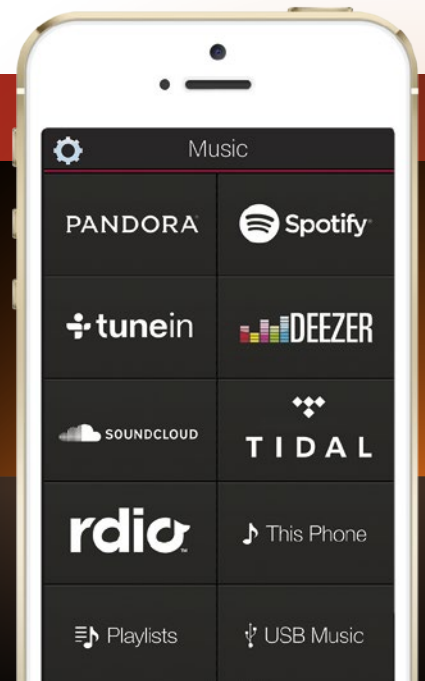
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We share with our readers a fascination
with science, technology, nature, culture
and archaeology, and believe that through
education about our past, present and future,
we can make the world a better place.

Someone is out there (probably)



As the editor of a science mag (which only makes me a scientist by association) I'm not overly troubled by the apparent "paradox" of why, in a universe old enough for super-advanced intelligence to evolve and colonise an entire galaxy, space appears to be empty of mind. Or at least empty of minds capable of manipulating entire stars and galaxies.

Astronomers and cosmologists who focus more intently on this problem and know a lot more about it than I do, deploy all kinds of complicated equations on either side of the essential argument: are we alone in the universe?

For me, as a mere commentator, the answer seems obvious. Of course we're not alone. The universe is so vast, any possible odds you put on the existence of aliens approaches 1:1, if you're prepared to widen the search enough.

I find it bizarre that after just 50 years of searching tiny slivers of electromagnetic spectrum in tiny slivers of sky, so many scientists declare even our galaxy empty.

Yet there are candidate signals that we've ALREADY received. Radio bursts of inexplicable mathematical symmetry, or power. Perhaps they can all be explained by natural causes (like the pulsars, which were originally called LGMs or "Little Green Men). Perhaps they can't.

There are two big problems in the search for extra-terrestrial intelligence. First, there's the sheer size of the galaxy compared to a single human. And second, there's the extreme shortness of a human lifespan, compared to how long it takes for anything interesting to happen in the galaxy.

So a human spends a few months staring

into space and then declares the joint empty. Meanwhile, the list of things that human could have missed seeing is... well, it's a pretty long list.

The problem of no aliens has been thought about in a lot of different ways by a lot of different people. Explanations for the apparent lack of ET-activity range from the depressing (all intelligent beings destroy themselves before they can make contact), the very depressing (all intelligent beings are wiped out by gamma ray bursters or supernovae before they can make contact), the mind-bendingly depressing (time and space are so vast and empty that all intelligent beings evolve and go extinct naturally without ever meeting each other) to the sci-fi and bizarre (we're part of a galactic nature reserve and other intelligent beings are not allowed to interfere with us).

Me? I think we're living in the early part of history and haven't had time to work all this stuff out yet. Since we only figured out there were other galaxies less than 100 years ago, I think it's premature to make any definitive statements about who may or may not be out there.

Another theory, and one I like, is that aliens are simply too strange and different, for us to be able to easily recognise with our current technology and understanding of science.

For the final word I'll turn to internet comic artist (and ex-NASA roboticist) Randall Munroe. An instalment of his strip XKCD titled "The Search" depicts two ants on a kitchen tile. One ant says: "We've searched dozens of these floor tiles for several common types of pheromone trails. If there were intelligent life up there, we would have seen its messages by now."

Anthony Fordham

Twitter: @sci_illustrated

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THINGS WE LEARNED IN THIS ISSUE

- + The **LARGE HADRON COLLIDER** would need trillions of AAs to run on batteries.
- + Humans may have a bigger and more complex **FAMILY TREE** than we realised.
- + You can **TAKE CONTROL OF YOUR DREAMS** with some simple mental tricks.
- + We need to **REINVENT THE WHEEL** to keep up with the future of transport.
- + To hear a **MESSAGE FROM ALIENS** we need to first guess how they'll send it.



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BENJAMIN GRANT/ SATELLITE IMAGERY COURTESY OF DIGITAL GLOBE/DAILY OVERVIEW

↓ CLOSE TO THE CASCADING WATERS

Since 1846, the boat “Maid of the Mist” has taken passengers intimately close to the 50-m-high Niagara Falls on the border between the US and Canada. More than 2,400 cubic metres of water flow through the three waterfalls per second during the summer, when the famous falls attract millions of tourists. For the rest of the year, a major portion of the water is diverted through several hydroelectric plants, which generate a total of 4.4 gigawatts of electricity.





Polyrhachis ant

ANTS PREFER OTHER SIZES ↓

Ants follow the golden rule of not killing creatures that are smaller than themselves, according to scientists from the Imperial College London, who have studied Bornean rain forest ants. In the jungle, big and small species live peacefully side by side, but as soon as an ant encounters an unfamiliar ant of the same size, it will attack. That is probably due to the fact that ants of the same size compete for the same resources.

TOM FANT



Pheidole ant

Editors: Karine Kirkebæk

PARAWING GLIDER TO LAND PROBES

A glider could land Mars probes with unprecedented accuracy.

AEROSPACE Before humans will be able to go to Mars, possible landing sites must be carefully examined. The terrain on our neighbouring planet is so impassable and hostile in some places that it is necessary to leave the exploration to miniature probes. American scientists from the Planetary Science Institute and NASA's Jet Propulsion Laboratory have developed a landing concept: The small landers will be sent to Mars aboard a larger spacecraft. When the craft reaches the Red Planet, the landers will

detach and use a steerable parawing to glide the microprobes to the surface of Mars. Scientists control the parawing by means of video equipment.

According to scientists' analyses, the probes can be landed within 10 metres of a desired spot. And due to their small size and sturdiness, they can go to places beyond the reach of NASA's Curiosity rover. The probes can be landed in gorges, on steep slopes, in areas with volcanic activity, and on glaciers.

Probes orbiting Mars such as Mars Express, landing probes such as Phoenix, and rovers such as Curiosity are now exploring Mars, but none of them can reach a glacier.

PROBE LOADED WITH GEAR

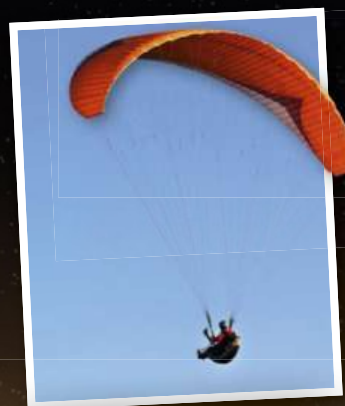
WEIGHT: 1 kg.

LENGTH: 30 cm.

LOAD: Camera, weather sensor, seismometers, microscopes, and other equipment for analysing the surface.

1 A capsule with parawing glider and probe detaches from a spacecraft, approaching Mars at a speed of 65 km/minute.

Capsule



The scientists were inspired by the paragliding technique with customized parachutes.

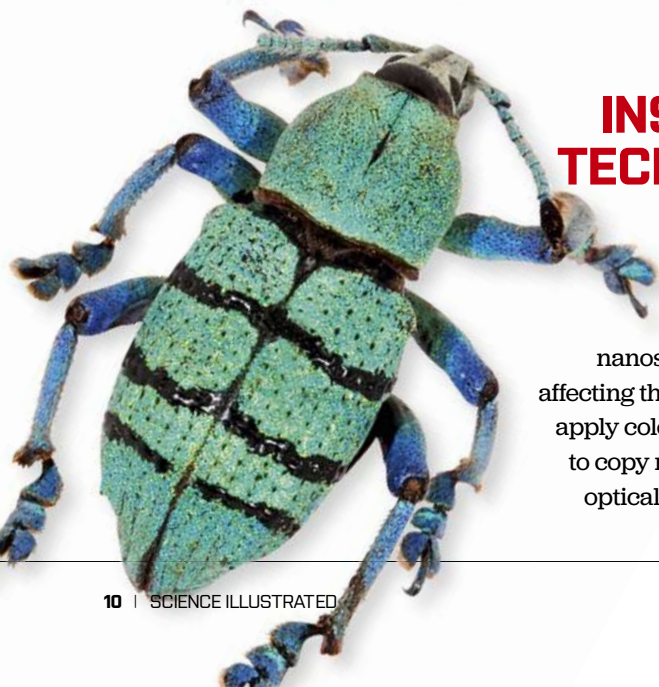
INSECTS ARE NANO-TECHNICAL WONDERS

Radioscopy carried out by the Yale University in the US has revealed that the surfaces of beetles, bees, and butterflies are full of nanostructures: perfectly organised crystals affecting the motion of light particles. The crystals apply colours to the insects, but scientists intend to copy nature, aiming to make improved fibre-optical cables, solar cells, make-up, and paint.

► NEWS FLASH!

TURTLES AND SNAKES ARE RELATED

Studies of a 240-million-year-old shell-less turtle reveal that it belongs to the animal group known as "diapsids", which also includes snakes. Not until a later point in evolution, the turtle developed a shell.



201 tortoises have been released on Galápagos Islands beaches. The species is the very same one that went extinct there 150 years ago.

PARAWING SLOWS DOWN DRAMATIC DESCENT

After falling 65 km down through the Martian atmosphere in just one minute, the parawing ensures a soft flight and landing. The parawing can glide for about 10 km.



2 The parawing unfolds. Half the capsule still protects the probe.

Parawing

3 The steerable parawing quietly carries the probe to the surface. The small probe is released from the capsule.

4 After 10 minutes, the probe lands a maximum of 10 m from the selected site.



OCTOPUS ARM HELPS SURGEONS

MEDICINE Using nature as their role model, a group of Italian scientists have designed an extremely flexible robotic arm to be used for surgery purposes. The arm can bend, stretch, and squeeze its way through cluttered environments. During surgery, it can gently lift an organ and hold it. The arm can also be completely stiff to steady an organ without the need of a human hand. The scientists intended the arm to be soft and without sharp edges, so it cannot harm fragile organs – contrary to metal instruments. The arm has been tested with fragile water balloons.

T. FRANZINI/HARVARD UNIVERSITY

MYSTERY OF MISSING LAKES SOLVED

CLIMATE Several times, huge lakes atop the Greenland ice sheet have been drained of billions of litres of water in just a few hours. Much to the amazement of scientists, a 4-km-long and 8-m-deep lake was emptied in an hour and a half in 2006.

Now, American scientists have solved the mystery of the missing lakes. The scientists knew that the

lakes were drained due to cracks at the bottom of the ice sheet, and now they also know how the cracks develop. Surface meltwater moves down, setting the ice sheet below the lake in motion. This produces massive tension which makes the ice below the lake crack, producing a huge drain through which the water of the lake can disappear.

A 4-km-long and 8-m-deep lake was emptied in 1.5 hours.



WHOI



STRANGE — BUT TRUE!

Flying man beats world record

A new hoverboard flying world record has been set: 275.9 m. Hoverboards are like skateboards without wheels. They fly by means of electromagnets located on the lower surface.



Beet juice helps keep roads safe

Scientists have discovered that beetroots, potatoes, and cheese brine contain enough salt to make icy roads safer. The salt concentration of the agricultural products is high and easy to extract. What's more, the method is cheap, environmentally friendly, and efficient at low temperatures.

MAP ENABLES LEGAL DRONE FLYING

TECHNOLOGY US drone enthusiasts have created a digital map of places, in which it is both safe and legal to operate an unmanned aircraft. Drone pilots add new data to the AirMap every day in an effort

to ensure safe, legal, and hassle-free drone flying. The empty spaces of the map are considered to be areas, where it is legal to fly drones – until data to the contrary is added.

Source: LANL

RUBBER GENERATES POWER

Stretch the rubber to generate power. A new flexible material from the Japanese company Ricoh can provide anyone with a small power plant. When crystalline materials such as quartz are stretched, they generate an electric charge.

The force at work is piezo-electricity.



▶ **41.8** million tonnes of electronics were scrapped in 2014. Particularly microwave ovens, washing machines, and dishwashers are accumulating at waste disposal sites. ◀

CHICKEN EMBRYOS GET DINOSAUR SNOOTS

Scientists have manipulated chicken embryos genetically to produce dinosaur snouts.

PALAEONTOLOGY Scientists from Yale and Harvard Universities in the US have bred chicken embryos with broad dinosaur snouts instead of their usual beaks. The snout resembles that of the bird-like velociraptor, a predatory dinosaur. Before going to the lab, the scientists studied both fossils and

living birds and reptiles to learn about the details of the genetic development of beaks, allowing them to carry out the genetic manipulation. In popular terms, they deactivated the genes that control the formation of beaks and activated the genes that cause the formation of snouts instead of beaks.

GENETICALLY MANIPULATED BIRD GETS SNOOT

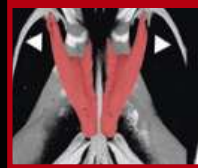
Scientists manipulated chicken embryo genes. CT scans show that embryos developed palate bones like dinosaurs.

BIRD



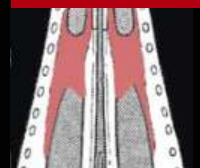
Modern birds have narrow palate bones in their beaks.

EXPERIMENT



Manipulated chicken embryo with snout and broad palate bone.

FOSSIL



Dinosaurs had broad palate bones in their snouts.

JOHN CONWAY & BRIAN ANJAN BHULLAR/YALE UNIVERSITY

YOUNG, THIN ICE AGGRAVATES FURTHER CLIMATE CHANGE

CLIMATE Previously, the Arctic Ocean around the North Pole was covered by ice all year, but the past 25 years have brought great change. Now, the sea ice melts every summer, and the shift from permanent ice to no ice in the summer may have climatic consequences. The new winter ice is thin and reflects some 10% less solar energy than the old,

thick ice. According to scientists from the Norwegian Polar Institute, about half of the solar energy is absorbed by the ice, that is melting faster than ever. The other half of the energy is absorbed by the ocean, making the temperatures of the abyss rise, and this could speed up climate change. The effects could even spread further.



Arctic Ocean drilling shows that the climate is warming up.

NORVEGIAN POLAR INSTITUTE



LOCAL FOCAL POINT

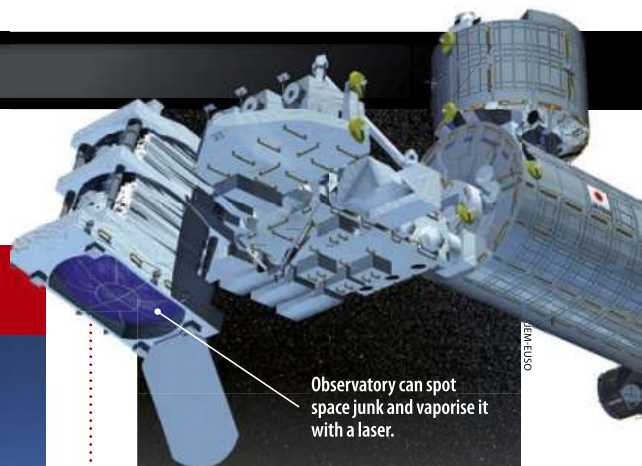
Everest region, Nepal



Glaciers melt on the roof of the world

Based on top of the glaciers in the Everest region of North-Eastern Nepal, scientists have studied how climate change will alter the glaciers in the future. Their results indicate that the glaciers will be dramatically reduced - perhaps as much as by 70-90 % up until 2100.

PATRICK WAGNON/VEGU



Observatory can spot space junk and vaporise it with a laser.

ISS LASER TO CLEAN UP SPACE

AEROSPACE In 2017, the Japanese part of the International Space Station (ISS) will be fitted up with the Extreme Universe Space Observatory (EUSO), which is going to detect cosmic radiation and neutrinos. But the observatory will also be able to spot potentially dangerous space junk from a great distance. So, it has been suggested to equip the observatory with a powerful laser cannon to "ablate" the junk, which will burn up in the atmosphere. The weapon would be able to combat the rising amounts of space junk.

FACTS ABOUT SPACE JUNK

According to NASA, some 3,000 t of space junk is orbiting Earth in the form of worn-out satellites and rocket parts. Even small junk can move at a speed of 36,000 km/h and be hazardous to the ISS.

HIGH-STATUS WOMAN BURIED IN STYLE

In a field in Norfolk, East England, British amateur archaeologist Tom Lucking has discovered a large collection of distinguished jewellery dating from approximately 650 AD. Mr Lucking unearthed the jewellery in a grave of a high-status Anglo-Saxon woman, whose last resting place was adorned with a 8-cm-wide gold pendant inlaid with over 400 garnets and other jewellery.

TOM LUCKING



8 CM



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A starfish can 'spit' foreign objects out of its leg, scientists found, when they tried to label the animal with a microchip. The tag kept coming out of the leg.

ROBOTIC COCKROACH HELPS BIRD FLY

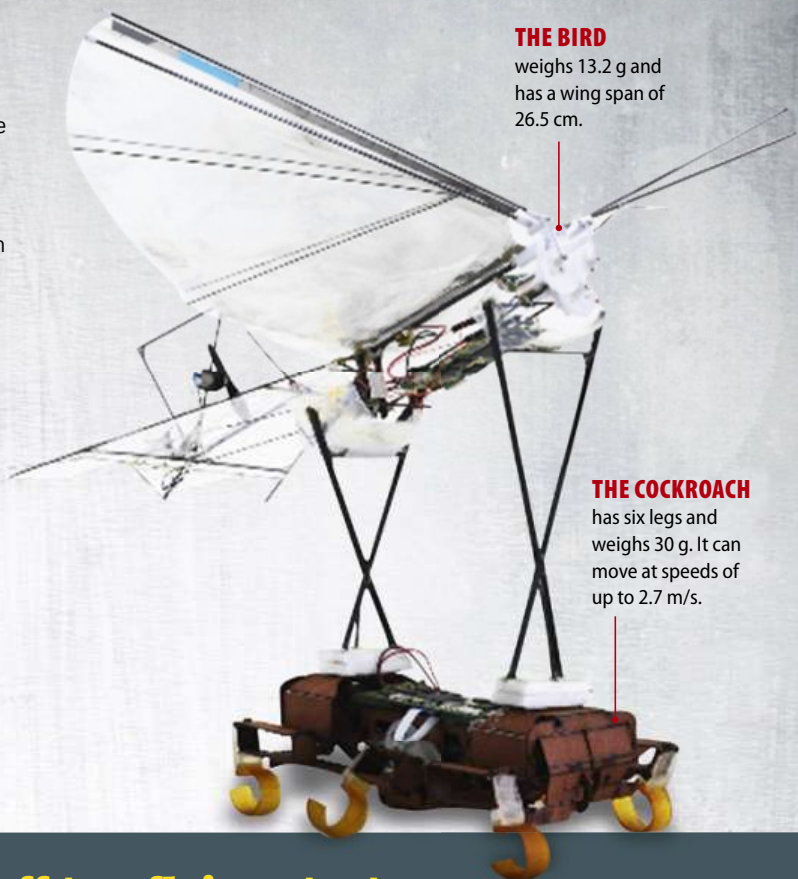
Two robots depend on each other to work optimally.

TECHNOLOGY Though a cockroach and a bird make up an odd couple, they are still able to cooperate perfectly – at least in their robotic versions. With the wing-flapping bird on its back, the cockroach breaks into a run, and at a speed of 1.3 m/s, when the bird's wings are at an angle of 35–40 degrees, the flyer takes off.

The scientists responsible for the invention are from the University of California, Berkeley, and they have turned the two very different robots VelociRoACH and H2Bird into partners that can both walk (or indeed run) and fly.

The two robots function better together than apart. Without the help of the fast cockroach, the robotic bird cannot take off, and when the bird is sitting on the cockroach's back, flapping its wings, the cockroach consumes 16 % less energy than it would have done, if it had not brought its mate along.

The scientists developed the cockroach and bird to show how two robots with different characteristics can cooperate.



THE BIRD

weighs 13.2 g and has a wing span of 26.5 cm.

THE COCKROACH

has six legs and weighs 30 g. It can move at speeds of up to 2.7 m/s.

Cockroach gets bird off to a flying start

The robotic bird needs assistance from the cockroach to take off. Both creatures are battery-powered and remote-controlled.



1. The robotic cockroach is set in motion by means of a remote control. The bird is attached to its back.



2. The robotic bird flaps its wings, increasing the speed of the cockroach and reducing its energy consumption.



3. When the cockroach moves at a speed of 1.3 m/s, the bird takes off. The angle between the wings is 35–40 degrees.



4. The bird flies and can remain in the air for up to 2.5 minutes, covering 20 m. The cockroach stays on the ground.

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Why do wounds itch?

It seems illogical that wounds itch, making us scratch and slow the healing process as a result. So why do wounds itch?

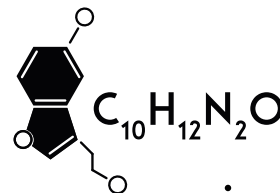
Healing wounds itch, as the healing process activates itching nerves in the outermost skin layer. The skin contains many different types of nerves, which are sensitive to cold, heat, pain, hard blows, or light pressure. Itching nerves react to very gentle, mechanical or chemical influences such as when a fly walks across your arm or a droplet of lemon juice makes your skin tingle. In the case of this type of influence, itching nerves inform the brain about an itching sensation.

During the healing process, the cells at the edge of a wound divide and migrate into the wound, where they unite and contract. So, they pull at the edges of the wound, allowing

the hole to close. When the skin cells move, the itching nerves of the area are activated. The itching nerves are also activated by chemical substances secreted into the wound in connection with the inflammatory condition of the skin.

The urge to scratch is triggered by a spinal reflex. The scratching behaviour is quite clever, as the itching stops, when we rub the wound, briefly curbing the activity of the itching nerves. But if we scratch so much that the wound starts to bleed, we may interrupt the healing process, so the wound takes longer to close and will perhaps leave a scar.

4 Some of the **serotonin** flows with the blood to the wound, where the serotonin reactivates the itching nerves, intensifying the itching sensation.



MOSQUITO BITE ITCH CONTINUES

Mosquito saliva causes an allergic reaction in the skin, making the bite itch. Scratching a mosquito bite can stop the itch for a while, as the activity of pain nerves around the bite increases. This is because the pain nerves curb the itching nerve signals. Nevertheless, it will soon itch again due to substances that reactivate the itching nerves.



SHUTTERSTOCK

HOW DID WE CLEAN TEETH BEFORE TOOTHBRUSHES?

Some 5,500 years ago, the Babylonians and Egyptians were the first to cleanse their teeth with wooden sticks that were frayed and wet at one end. About 3,600 years ago, the Chinese used chewing sticks made of aromatic wood as toothbrushes. The sticks cleansed the teeth and ensured fresh breath.

ARCHIVE

IN SHORT

CAN WE GET TOO MANY VITAMINS?

The body regulates vitamin levels, but if you consume too many, the balance may be disrupted. Three times the recommended daily dose of vitamin A for six months may cause blurred vision, hair loss, and skin problems.

Natural mechanism makes a wound itch

Paradoxically, the itching of a wound is activated by the healing process, when cells make the edge of the wound contract.

1 Itching nerves in the skin are activated by **the healing process**, when the wound contracts, etc. The nerves inform the brain about the itching.



2 The brain registers the itching signals, so the person starts to scratch. **Pain nerves** in the wound are activated, stopping the person from scratching too much.



3 **The brain** receives the pain signals, and the hypothalamus brain centre tries to relieve the pain by means of serotonin.



The Japanese spider crab's legs can span 4 metres.

TOP5

WHICH IS THE BIGGEST CRUSTACEAN?

1. Japanese spider crab

Leg span: up to 4 m
Shell width: up to 60 cm
Weight: up to 20 kg

2. Red king crab

Leg span: up to 2 m
Shell width: up to 30 cm
Weight: up to 10 kg

3. Tasmanian giant crab

Leg span: up to 1.5 m
Shell width: up to 50 cm
Weight: up to 13 kg

4. American lobster

Leg span: up to 1.2 m
Weight: up to 27 kg

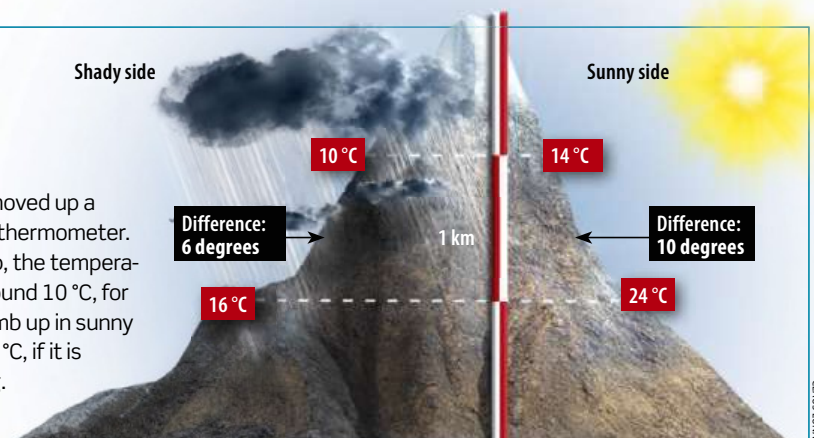
5. Coconut crab

(a type of large terrestrial hermit crab that lives on Christmas Island)
Leg span: up to 1 m
Weight: up to 4 kg

HOW DOES ELEVATION AFFECT TEMPERATURE?

As we climb a mountain, it will gradually get colder, but temperatures often vary depending on geography, as climatic zones, seasons, and weather conditions all play a role. Nevertheless, it is possible to calculate how many

metres we have moved up a mountain using a thermometer. As a rule of thumb, the temperature will fall by around 10 °C, for every 1 km we climb up in sunny weather, and by 6 °C, if it is snowing or raining.



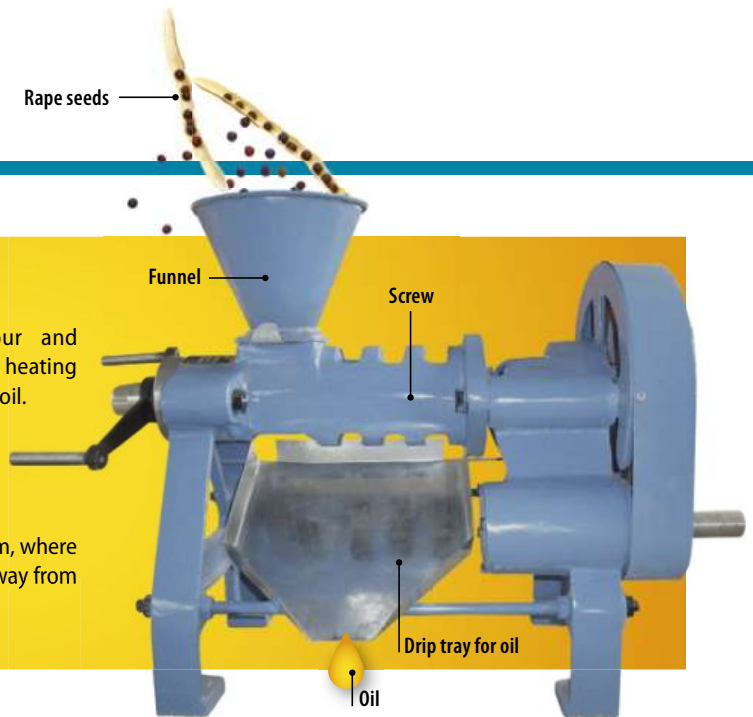
HOW IS COOKING OIL MADE?

Cooking oil is made by either hot or cold pressing of olives, sunflower seeds, rape seeds (canola), corn, or the like. Cold pressing produces the most flavourful oil and is done by pressing seeds without heating.

The mass of seeds remaining after cold pressing can be heated to about 100 °C and pressed again. Hot pressing produces more oil, but

impurities such as flavour and pigments produced during heating must be removed from the oil.

A screw press is typically used to produce oil from hard seeds. The seeds are poured into a funnel and move on into a screw or worm, where the oil is pressed, dripping away from the seed coat.



AGICO

NATURE IN ACTION

WHY DON'T FLOCKS OF BIRDS COLLIDE?

A bird's ability to manoeuvre close to its companions is due to fast reflexes. Small birds have particularly quick reflexes, as their sensory organs and brains are located closer to each other. According to scientific research, starlings keep an eye on 6-7 other birds, explaining how a flock can change shape without the birds at the edges dropping out.

EYES: Birds have a high "flicker rate" - their eyes can see fast motion as a series of images, allowing them to steer clear of obstacles.

BODY: Birds probably notice airflows produced by other birds, allowing them a few more milliseconds to react and avoid a collision.

Birds stick together in flocks as a defence mechanism against predators. A solitary bird is more vulnerable to an attack.

SHUTTERSTOCK

Is it dangerous to stand in front of a microwave oven?

Microwaves are effectively stopped by the oven cabinet. According to law, the oven can only leak 5 mW/cm^2 – less than that of sunlight.

WHY DO ASTRONAUTS PRACTICE UNDER WATER?

I heard that astronauts practice for space missions under water in large pools. Is that true?

When astronauts prepare themselves for spacewalks, they do it in large bodies of water to simulate weightlessness. The astronauts put on copies of real spacesuits before entering the water. There, they are equipped with weights to ensure that they remain neutrally buoyant in the water – they do not float or sink. The astronauts must feel that they are drifting

freely. The exercises consist of using different tools in a state of weightlessness and mounting or maintaining modules.

Of course, in the pool, the astronauts can still feel their own weight and sense if they are upside down – but not in space. Moreover, the water offers resistance, so exercises under water are not ideal, but they are still extremely important.

In the water tank, there are full scale models of space stations, so the astronauts can train for real missions.

YES, THE WORLD'S BIGGEST POOL IS AMERICAN

■ **USA:** At NASA's space centre in Houston, astronauts practice in the world's biggest indoor pool containing 23.5 million l of water.

■ **Russia:** The most important training centre, Yuri Gagarin, has windows in its sides. Everything can be filmed/analysed.

■ **China:** Taikonauts practice spacewalks in a 10-m-deep, circular water tank with a diameter of 23 metres.

■ **Japan:** JAXA, the Japanese space organisation, owns a 10.5-m-high tank with a 16 m diameter. The tank can hold a replica of the Japanese ISS module Kibo.



NASA

IN SHORT

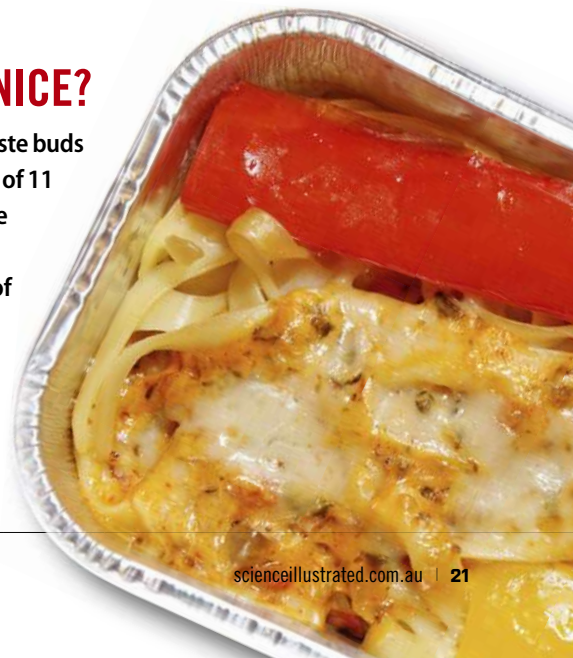
HOW IS SPAM E-MAIL IDENTIFIED?

The e-mail software looks for warning signals such as only capital letters in the subject field or for phrases such as “click now” or “lowest price”. Each e-mail gets a total score, and if it is too high, the e-mail is considered to be spam.

WHY ISN'T PLANE FOOD NICE?

The low pressure in the cabin makes our taste buds lose sensitivity. When you fly at an altitude of 11 km, the pressure and oxygen content in the cabin is as low as on a 2,000-2,400 m high mountain. The pressure reduces the taste of salt and sugar by 20-30%, but acid and bitter tastes register just as well as they usually do. So on many airlines, menus consist of spicy or heavily sauced meals, designed to mask bitterness. Yerk.

SHUTTERSTOCK



ASK US

THE ANSWERS
TO LIFE'S
LITTLE MYSTERIES



DO ALL FISH HAVE SCALES?

Scales protect fish. Some fish only have scales at the front or back of their bodies or a few rows of scales along the length of their bodies. Other fish are completely naked – such as the psychrolutidae, a group of mid-sized, bottom-dwelling fish, which resemble overgrown tadpoles with their big, round heads, small bodies, and slim tails. Psychrolutidae can grow 60-70 cm long. Some species are soft and slimy, whereas others have tough, leathery skin.

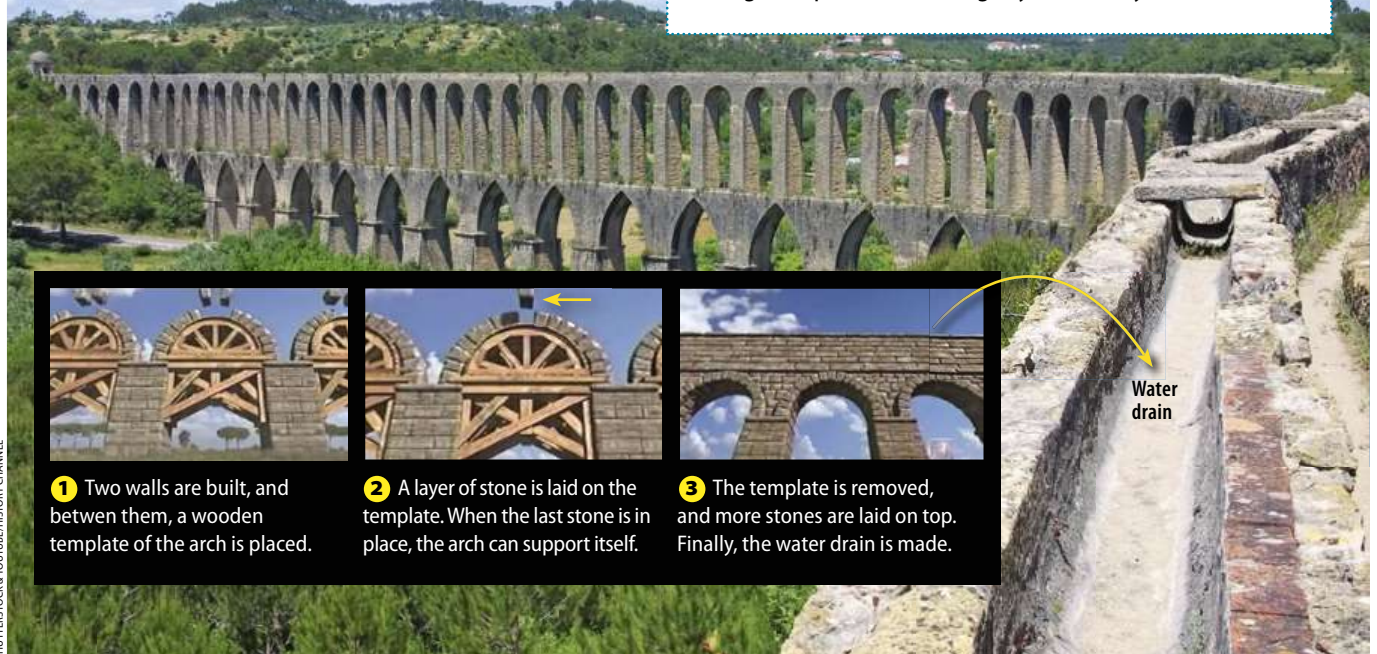
KERIN JARRISON/AUSTRALIAN MUSEUM

HISTORICAL WONDERS

The Romans were not the only ones to make aqueducts. The Portuguese built the Pegões Aqueduct, which is located in central Portugal.

HOW DID THE ROMANS BUILD AQUEDUCTS?

The Romans ensured water supply for big cities by means of aqueducts that carried water from a source or a lake to a city located up to 100 km away. The aqueduct system consisted of a network of underground canals and bridges sloped downhill slightly all the way to the end.



1 Two walls are built, and between them, a wooden template of the arch is placed.



2 A layer of stone is laid on the template. When the last stone is in place, the arch can support itself.



3 The template is removed, and more stones are laid on top. Finally, the water drain is made.

Water
drain

How fast do earthquake waves spread?

Scientists can predict earthquakes by detecting a P wave that arrives approximately 1 minute before the quake. The wave travels speeds of over

→ **18,000 km/h**

Is it really true that ... **... we can become invisible?**

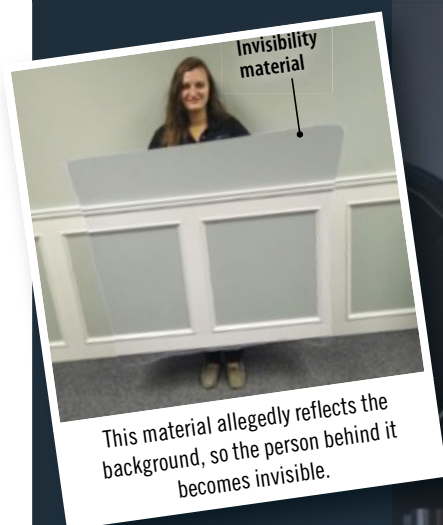
In the Harry Potter novels, Harry has an invisibility cape. But is it possible to become invisible in real life?

For a long time, scientists have tried to develop materials that can make the wearer invisible. The materials either reflect the background or bend the light around objects.

However, many of the materials do not work in visible light, so their ability to make things invisible is relatively poor. Instead of a cape, the effect can be achieved using glass.

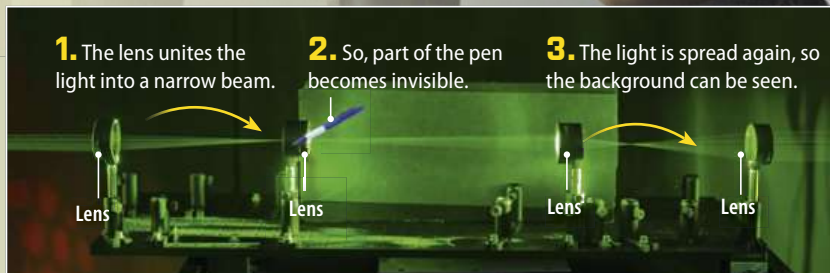
In 2014, scientists from the University of Rochester, New York, invented a system consisting of four optical lenses that bend the light to make objects invisible from several angles. The system is simple and cheap, and according to scientists, it can easily be scaled up to hide large objects.

A system of optical lenses bends the light, efficiently hiding objects in certain zones.



LENSES BEND THE LIGHT

The setup consists of four lenses, which can refract the light. So, the light does not shine on objects in a ring-shaped zone around the light beam, and objects in the zone cannot be seen through the front lens.



CONTACT WITH SPACE

There are 10 brief radio bursts which have excited astronomers. The signals are characterised by a mathematical regularity, which cannot have been caused by any known space phenomena. It means our search for life in the universe could already be over... we just don't know it yet.

By Mette Iversen

The Parkes telescope in Australia has detected several inexplicable radio signals.

CSIRO

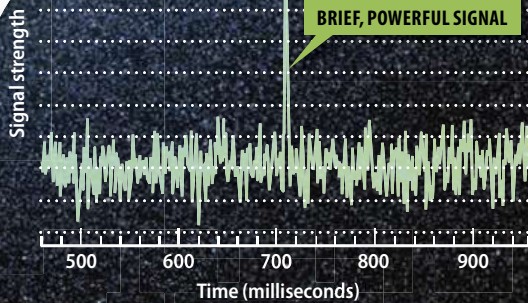




SIGNAL FROM SPACE

Did space send us a message?

Telescopes on Earth have received ultrabrief signals that could hold meaning... maybe.



The strange radio signals last a few milliseconds. The latest one was detected on 14 May 2014.



SIGNAL TO SPACE

How should we reply?

Scientists mean to send the entire Internet into space to explain who we are.



The radio signal only lasts a few milliseconds, but it contains as much energy as the Sun emits in one month. The electromagnetic signal, which is picked up by the Parkes radio telescope in NSW on 14 May 2014, is the tenth in a sequence of fast radio bursts (FRBs) received since 2001, but it is different in one important way: For the very first time, scientists register the signal as it is received, not by analysing "old" data. The Parkes astronomers immediately ask the other

telescopes of the world to focus on the signal, so space can be observed at other wavelengths. But neither X-rays, nor visible light or radio waves manifest themselves. The universe falls silent again.

For more than 50 years, scientists have been listening for messages from other intelligent creatures in the universe, but so far, they have not received a signal which definitively proves that we are not alone.

The 10 FRBs attract intense interest from astronomers, as the signals apparently

contain a simple mathematical message that cannot be explained by known cosmic phenomena. Are aliens trying to get in contact with us?

SIGNALS INCLUDE THE NUMBER 1875

Two scientists, Michael Hippke from the Institute for Data Analysis in Germany and John Learned from the University of Hawaii, decide to scrutinise the FRBs. Their study, which they publish in March 2015, ►



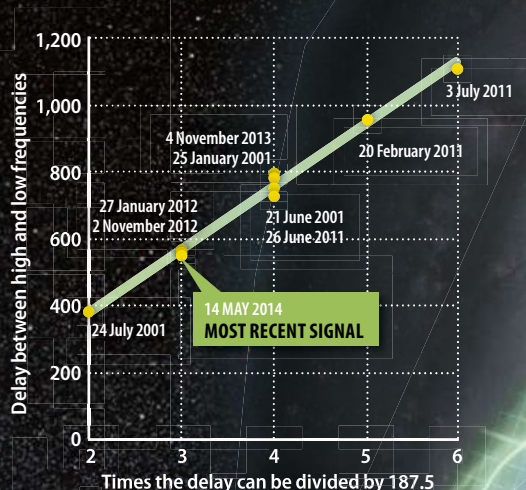


SIGNAL FROM SPACE

Aliens may be sending us a number

Are aliens sending us the number 187.5? 10 times within the past 14 years, astronomers have detected a radio signal that may contain this mathematical message. The number appears when scientists measure the time gap between the first and the last part of each signal. On their way through space, radio signals are spread by electrons, so high frequencies arrive slightly faster than low

frequencies. The longer the distance, the wider the dispersion (the dispersion measure). The inexplicable element is that the dispersion measure of all 10 signals can be divided by 187.5. The likelihood that the signals come from such evenly distributed natural objects is minimal, so scientists will not rule out that the signals could come from smart aliens using mathematics to communicate with us.



10 times we have detected the same signals, in which the delay between high and low frequencies can be divided by 187.5.

Which frequency will ET use?

Radio telescopes cannot listen in on all frequencies at a time, so the question is which part of the radio spectrum it makes sense to tune into. Many telescopes listen between 1,420 and 1,666 MHz, where there is less background noise from the universe, but

1,420 and 1,666 MHz are also the wavelengths that can be emitted by hydrogen and hydroxyl, respectively. The two materials combine into water, which is the prerequisite of life, and perhaps aliens would choose these frequencies, if they wanted to get in contact with us.

► concludes that all the bursts seem to communicate the same number.

Physicists use a phenomenon known as the “dispersion measure” to calculate how far away radio signals originate. Each FRB signal is found across a broad spectrum of radio frequencies – as if all FM radio channels were playing the same tune. On its way through space, the signal encounters particles that slow it down, but lower frequencies are slowed more than high ones. So, the high frequencies arrive to Earth a brief moment before the low ones, and scientists can measure the delay as the dispersion measure.

The sensational thing is that all 10 FRB signals we have received involve a delay that can be divided by the number 187.5, immediately indicating that the signals come from another galaxy with several sources

located at an evenly distributed distance from Earth, but scientists consider that to be an unlikely coincidence.

According to Hippke and Learned, the signals must come from one or more sources much closer to Earth, in our own galaxy, naturally or purposefully sending signals with a specific delay between high and low frequencies.

As long as we have only received a few signals, the pattern could be random, but the scientists consider the likelihood of that to be 5 in 10,000. The more FRBs we receive, the more mysterious it gets, and according to Hippke and Learned, the signals must either be due to an unknown physical phenomenon or come from an artificial source. A mathematical message is just what we would expect to receive from intelligent aliens.

But according to other scientists, it is still too early for conclusions. In their opinion, we need more time and perhaps new technology to find the cause.

WE MUST SEND MESSAGES TO STARS

One month before Hippke and Learned publish their results, leading astronomers participated in a conference in the US city of San Jose, discussing whether it is time for us to send signals into space. At the conference, which was hosted by the SETI (Search for Extraterrestrial Intelligence) institute, the leading body in the search for intelligent life, the head of the institute's research department, astronomer Seth Shostak, declares that he has had enough of just listening.

“Some of us at SETI would like more active SETI research. Instead of just listening,



SIGNAL TO SPACE

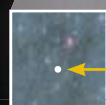
Our radio signals travel through the Milky Way

Humans have used radio waves to communicate for about 100 years. The electromagnetic waves travel in all directions at the speed of light, so today, our radio communication covers a sphere with a radius of 100 light years around Earth. If there are aliens within this region, they could (with a lot of technology) theoretically have watched our TV programmes. But in comparison, Earth's galaxy, the Milky Way, measures 100,000 light years across and is just one of billions of galaxies. Statistically, it is consequently much more likely that

any intelligent life would exist far beyond the reach of our radio signals.

Another problem is constituted by the fact that like visible light, radio waves become weaker and weaker the further away from the sender they travel. When the distance is doubled, the signal strength is reduced to 25%, and in the end, it becomes impossible to distinguish from the background noise of the universe. The signals can reach much further, if they are focused in one direction, and perhaps we will aim signals at Earth-like exoplanets in the future.

10,000 light years



Our radio signals cover a circle with a 200 light year diameter.

Aliens can watch "Star Trek"

Our TV programmes travel at the speed of light, so aliens 50 light years from Earth have been able to watch the first episodes of Star Trek.

Present reach of TV transmissions

1928 The first TV transmission

1951 The first colour TV programme

1966 The Star Trek TV series

1993 The X-Files TV series

Light years

50

40

30

20

10

Earth

we wish to send signals to the stars nearby, as perhaps we could attract someone's attention and get a reply," says Seth Shostak.

His statement causes a stir among other scientists, who warn against attracting attention from civilisations that are probably thousands or even millions of years ahead of us in their development.

So far, SETI research has mainly been about listening and waiting, but Shostak is not the first person to think about sending a message in the opposite direction. In 1974, the Arecibo radio telescope in Puerto Rico sent a coded message in the direction of the M13 star cluster on the outskirts of the Milky Way, and since then, humans have tried to get the attention of aliens several times. For 40 years, the Voyager 1 and 2 and Pioneer 10 and 11 probes have been travelling through space with images,

music, messages in 55 languages, and a map indicating our Solar System's location in the universe. But Shostak's initiative is ground-breaking, as he wants to step up the messages from Earth quite a lot such as astronomers aiming signals at distant stars as a matter of routine, every time they activate the big radio telescopes.

SCIENTISTS IN CONTACT WITH SPACE

The suggestion of making a greater effort to attract attention to the existence of Earth is made after more than 50 years of listening in vain – to "the great silence".

The search for intelligent life in space seriously began on 8 April 1960, when a pioneer of SETI research, American astrophysicist Frank Drake aimed his radio telescope at the sunlike star Tau Ceti for the

very first time. By means of a pen that printed the signal on a piece of paper, the young scientist could observe any radio signals coming from the region around the star. But the pen showed no signs of activity.

Instead, Drake aimed his telescope at the Epsilon Eridani star, once again observed the motions of the pen. And almost immediately, something happened. The pen moved eight times to both sides, as the lab speakers produced eight loud sounds. The surprised astronomer first believed that he had made contact with space, but he was badly disappointed, as the signal came from Earth, probably from an aircraft.

Although it turned out to be nothing, Drake's effort marked the beginning of SETI research. Since 1984, the research has primarily been carried out by the SETI institute, a private Californian ►

► organisation, which cooperates with the US space organisation NASA and others. Over the years, scientists have picked up inexplicable signals several times, but of course none of them have been proved to come from intelligent sources.

12 TELESCOPES AIMED AT SIGNAL

The first of the 10 mysterious FRBs was detected in 2007, when scientists analysed archive material from the Parkes telescope. When they continued the investigation, the telescope proved to have received several of the ultrabrief, but extremely powerful radio signals. The Arecibo telescope in Puerto Rico

had also registered an FRB. The astronomers began to develop a technique for observing the signals live, and they succeeded for the first time in May 2014.

Scientists have considered all known natural radiation sources to find a possible cause of the electromagnetic signals. Based on how brief the signals are, scientists can calculate that the source is relatively small. So, the signals cannot have come from an ordinary star.

If the radiation had been caused by an exploding star, a supernova, we would expect additional X-ray and gamma radiation, but when 12 telescopes aimed their discs at the source immediately after the burst of last

year, there was no radiation. Consequently, a supernova seems out of the question.

The residual product of a supernova, a neutron star, could also be a source, but scientists do not immediately think that neutron stars would be able to emit such powerful radio waves. Perhaps the radiation is due to cosmic laws of neutron stars that we do not yet understand. Others indicate that the source could be black holes or that the bursts are emitted when stars collide.

But no known cosmic phenomenon can explain the regularity of the signals. According to Hippke and Learned, we could be dealing with something as down-to-earth as a mobile transmitter or perhaps a spy satellite that has not been detected. But as long as nothing has been confirmed or denied, a signal from intelligent aliens cannot be ruled out. Yet.

MAY CONTAIN HIDDEN MESSAGE

The mysterious FRBs are ultrabrief signals on a broad spectrum of frequencies, and according to American SETI scientist David Messerschmitt, that is the type of signal which a remote civilisation would send. If the aliens do not just want to attract attention to their existence, but also want to send a message, it is the most efficient method, he says.

But although the method is efficient, it still requires much more sophisticated technology than ours to send that type of signals to other solar systems. Russian astrophysicist Nikolai Kardashev has divided civilisations into three types, according to whether they can control the energy of a planet, a star, or a galaxy. Our civilisation is far from being able to take advantage of all the energy on Earth, whereas the FRB signals can only have been sent by a civilisation that utilizes the energy of an entire star.

Our technological limitations mean that there is a limit to the small variations we can decode based on brief radio signals. But perhaps the aliens' message is the tiny variations of one tenth or one hundredth of a millionth of a second.

Not until the day we receive a concrete message, we can surely say that we have made contact with other intelligent creatures. And we are still waiting for such a signal. If the 10 mysterious FRB signals contain a message to us from an alien civilisation, we are not yet able to decode it. But we're working on it. **SCI**

SHOULD WE CONTACT THE ALIENS?

Would it be a good idea to try to attract the attention of alien civilizations? Scientists seriously disagree.

NO, *they will take over Earth*

If a remote civilisation is able to pick up and translate our signals and seek out Earth, it is much more sophisticated than we are. American physicist David Brin is one of several prominent scientists, who warn against contacting other intelligent creatures. He reminds us how badly things have gone in the past, when high and low tech cultures have met – like when Columbus came to America. If we are visited by alien spacecraft one day, it could be just as bloody, he believes.

YES, *they are old and harmless*

On Earth, we have only had the technology to wipe out ourselves for 70 years, and still, we have come very close to a nuclear war several times. An alien civilisation that has developed the technology to travel to foreign solar systems must be much more sophisticated than we are. And if it has managed to become so old without destroying itself, it must have learned to live in peace, according to the scientists who are in favour of contacting the aliens.

Do alien civilisations
have more dangerous
weapons than ours,
or have they learned to
live in peace?



SIGNAL FROM SPACE

A history of false alarms

In the past 50 years, astronomers have picked up mysterious signals from space several times – signals caused by unknown cosmic phenomena... or aliens trying to get in contact with us?

1967

Green men were pulsars

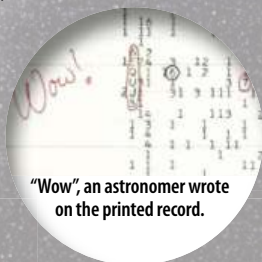
EXPLAINED: Scientists pick up signals with a steady, 1.33 second rhythm. The inexplicable signals are referred to as "little green men", but later, they turn out to have been caused by a so far unknown phenomenon – pulsars.

1977

Wow signal was never repeated

UNEXPLAINED: "Wow", an astronomer writes on the printed record of a 72 second radio signal 30 times more powerful than the space background radiation. The signal from the Sagittarius constellation is never repeated.

OSU/NAAPO



"Wow", an astronomer wrote on the printed record.

2008

Ultrabrief laser pulse

UNEXPLAINED: An ultrabrief laser pulse from the 47 Tucanae star constellation is observed by an astronomer. "Is this ET?" he writes on the printout. No known phenomena can explain the small light particle increase. A six month search for a new laser pulse is fruitless.

A brief laser pulse is emitted from the 47 Tucanae constellation.

2003

Known frequency signal

UNEXPLAINED: The Arecibo radio telescope picks up three radio signals named SHGb02+14A. The signal is sent at 1,420 MHz, one of the frequencies that scientists expect aliens to use to contact us.



SIGNAL TO SPACE

Which message should we send?

How should we communicate with aliens? During a period of more than four decades, we have sent 18 messages into space, but many scientists doubt whether smart aliens will be able to understand the messages.

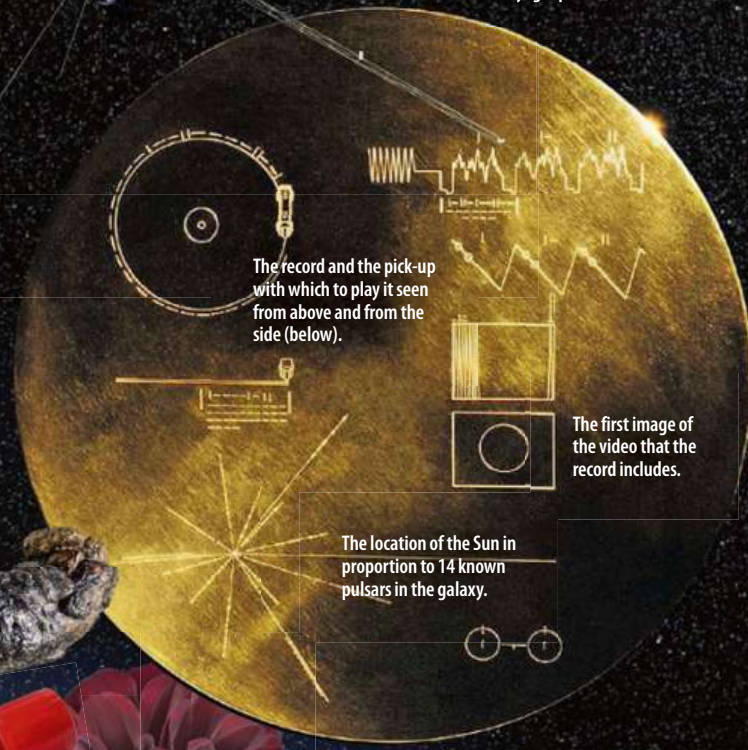
At a conference hosted by the SETI research institute last year, astronomers, linguists, anthropologists, and artists met to discuss what a message should be like to be understood throughout the universe. According to one of the participants, Carrie Peterson, who is an artist, we should send the chemical formulas of Earth's smells – such as blood, flowers,

faeces, and petrol – as the sense of smell is the most basic one. Seth Shostak, who heads the SETI institute's research branch, thinks that we should send the entire Internet, as large amounts of information will make it easier to work out the code to our languages and culture.



Voyager 1

The golden record was launched in 1977 with the two Voyager probes.



The record and the pick-up with which to play it seen from above and from the side (below).

The first image of the video that the record includes.

The location of the Sun in proportion to 14 known pulsars in the galaxy.



In the future, we may send Earth's smells such as those of blood, faeces, and flowers.

scienceillustrated.com

MISSING

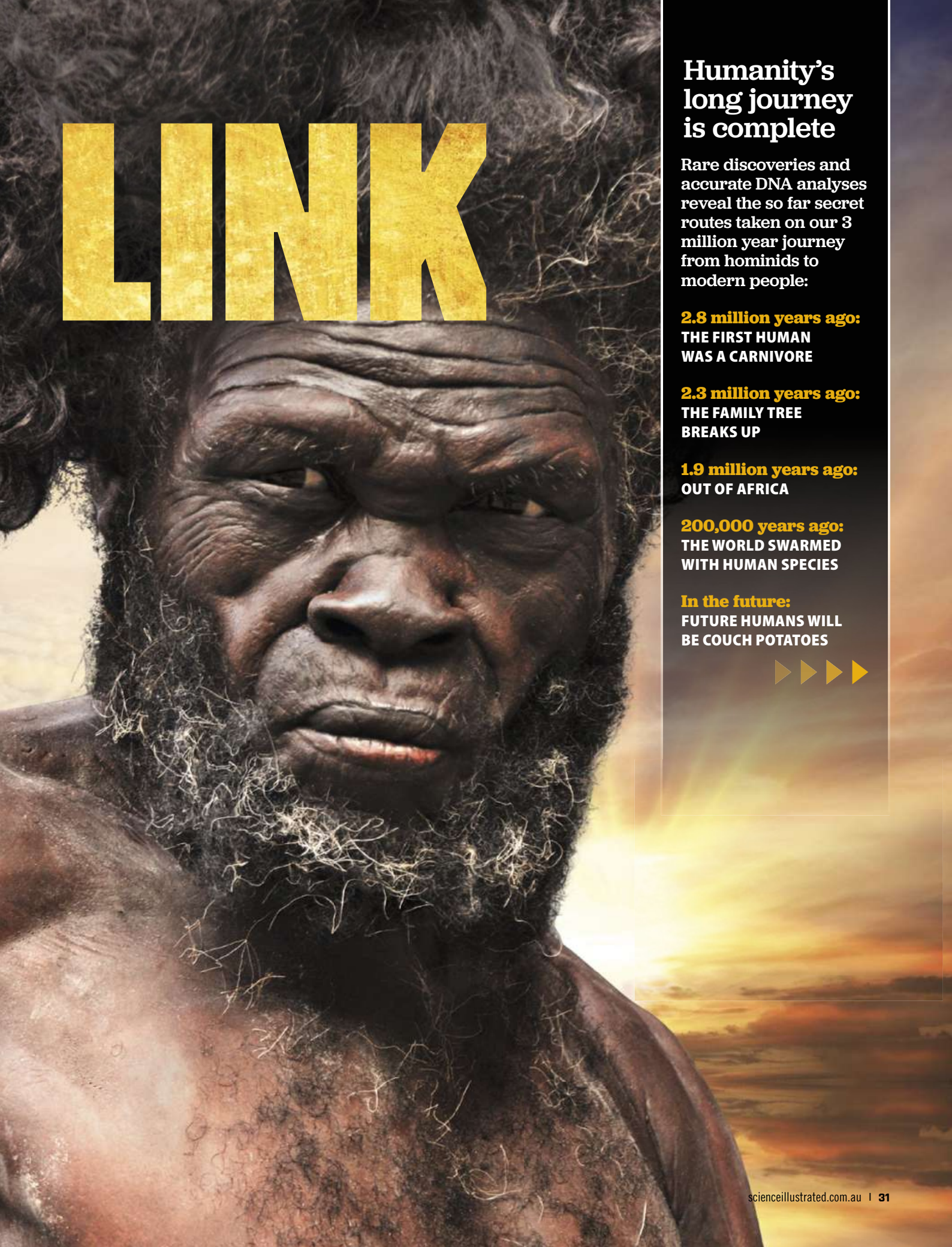
A battered jaw discovered in the bone-dry soil of Ethiopia features human-like teeth and hominid-like bone. So, the fossil is the missing link connecting us directly with the hominids, providing us with the missing chapter in the history of the human race.

By Rasmus Kragh Jakobsen

The 2.8-million-year-old jaw is thick like a hominid's, but includes small, homogenous teeth like those of humans.

KENNIS & KENNIS RECONSTRUCTIONS

LINK



Humanity's long journey is complete

Rare discoveries and accurate DNA analyses reveal the so far secret routes taken on our 3 million year journey from hominids to modern people:

2.8 million years ago:
THE FIRST HUMAN
WAS A CARNIVORE

2.3 million years ago:
THE FAMILY TREE
BREAKS UP

1.9 million years ago:
OUT OF AFRICA

200,000 years ago:
THE WORLD SWARMED
WITH HUMAN SPECIES

In the future:
FUTURE HUMANS WILL
BE COUCH POTATOES





THE FIRST HUMAN WAS A CARNIVORE

Small teeth in a broad jaw. An international team of scientists have discovered a fossil giving away the identity of the primitive hominids who stood up and walked approximately 3 million years ago, becoming the first humans.

Come over here! The cry echoes in the dry Afar region of Ethiopia in the spring of 2013. An international team of palaeontologists headed by William H. Kimbel is carrying out excavations, and on the ground in front of the scientists lies an old lower jaw with five teeth.

Back in the lab, the jaw proves to be 2.8 million years old. So, it is not only 0.5 million years older than the oldest known human fossils. The find also dates back from a period of 1 million years, from which scientists have no fossils; a period when humans come, and hominids go.

The teeth of the new find are even small like those of humans, whereas the jawbone is thick and inclining like those of hominids. The owner of the jaw may very well be the first human in the world. Along with new reconstructions of 2 old finds, the studies

indicate that the first humans can be identified by their teeth.

DISCOVERY PLACES CRADLE IN AFRICA

The story about the jaw began in 1960, when palaeontologists and spouses Mary and Louis Leakey find a 1.8-million-year-old human skull in Tanzania.

Back then, most scientists agreed that the first human originated some 1 million years ago in Asia and was a *Homo erectus*. According to the scientists, the first humans had spread to Europe, over time evolving into Neanderthals and later into us, *Homo sapiens*.

But Louis Leakey thought differently. In the 1930s, he had found a number of 2-million-year-old stone tools in the Olduvai gorge of Tanzania. So, he believed that the first humans had been born there, and he

instituted a search for more evidence in impassable East Africa.

In April 1964, the Leakeys were finally able to publish the discovery of their dreams, OH 7, in the shape of a skull and some hand bones. The skull featured human teeth and a small brain, which was only slightly larger than a chimp's. But the Leakeys' trump card was the short fingers of the hand, which could both grip and make tools.

Named *Homo habilis*, the find fitted perfectly into Leakey's theory that stone tools were what seriously made the first humans differ from the primitive hominids, the stage between humans and monkeys.

The tools allowed access to energy-rich meat and fat, which provided nourishment for the brain to grow. The small teeth revealed a shift in diet to more meat, and the brain had become slightly bigger. ►

The five teeth's crowns and roots have characteristic human features. The molars are small and slim, and all teeth are about the same size.

The jawbone shape, including a sloping chin and a thick bone, is similar to that of hominids living in the Afar region some three million years ago.



Missing Link



1. Large brain

Human brains are markedly bigger than those of earlier hominids. The brains of the first humans were about 0.5 litres, subsequently increasing to 1.5 litres. A large brain allows for more complex thinking.



2. Flat face

Unlike other primates, the human face is vertical and lacks powerful jaw muscles, indicating the consumption of a less demanding diet and allowing space for a larger brain.

5 human features

Humans are the descendants of small hominids, who lived in East Africa 3 million years ago. Like their ancestors, the first humans were small, but they boasted a series of new characteristics.



3. Small teeth

The formidable canine teeth of monkeys have been replaced by small teeth throughout the mouth, indicating a change of diet involving fewer tough and hard plant parts and more energy-rich meat and fat.



4. Pincer grip

Human hands and fingers are short, and the tip of the thumb can approach the other fingers in a so-called pincer grip. The new grip provides improved fine motor skills, meaning that we can make and hold on to tools.



5. Upright walk

From the "springed" foot and the shape of the pelvis to the location of the skull, the body is designed for upright walk. The build shows that the first humans left the trees for the ground, conquering new habitats.





Humans were born in East Africa

East Africa has been named the cradle of humanity over and over again, as the region is bursting with evidence and fossils of both the first humans and the last hominids.

MIKKEL JUUL-JENSEN

MISSING LINK



Hominid distribution



2 THE FIRST HUMAN

The newly found jaw is the oldest evidence of humans and boasts features of both hominids and humans.
Age: 2.8 million years
Species: Unknown Homo species



5 SOUTH AFRICA HAS PRODUCED YET ANOTHER ANCESTOR

In the Sterkfontein region of South Africa, scientists have found several hominid fossils such as "Little Foot", which is the by far most complete hominid ever discovered. Almost all bones have been preserved, located in their original position. Right now, scientists are waiting for the final description of the fossils, which could reveal, whether humans descend from one single lineage or a wide range of hominids.

Age: 3.67 million years
Species: Australopithecus prometheus

WITS UNIVERSITY/REUTERS/SCANPIX

POSSIBLE ANCESTOR



THE LAST HOMINIDS

2 ANIMAL BONES PROVE USE OF TOOLS

Cut marks in 3.4-million-year-old antelope bones bear witness that hominids used stone tools to kill animals.

Age: 3.4 million years
Species: Unknown

1 SMALLER BRAIN THAN THAT OF HUMANS

A skull and other fossils from a 3-year-old girl show that the brain was smaller than ours.

Age: 3.3 million years
Species: Australopithecus afarensis

3 FOOTPRINTS REVEAL UPRIGHT WALK

The so-called Laetoli footprints are the oldest evidence that unlike monkeys, hominids could walk on two legs.

Age: 3.7 million years
Species: Au. afarensis

4 HOMINIDS USED TOOLS

Scientists recently found the oldest known stone tools, Lomekwi tools. They were definitely made by hominids.

Age: 3.3 million years
Species: Unknown



THE FIRST HUMANS

3 HOMO HABILIS WAS A DEAD END

The OH 7 fossil featuring a large brain and a primitive jaw was probably an evolutionary dead end.

Age: 1.8 million years
Species: Homo habilis

OUR ANCESTOR

2 JAW POINTS FORWARD

The so far oldest known remains of a human being, the AL 666-1 jaw, boasts teeth resembling those of later human species.

Age: 2.3 million years
Species: Unknown Homo

THE LAST HOMINID

2 UNSTEADY, ROLLING GAIT

The Lucy fossil is our best shot of a direct ancestor. Lucy could walk upright, but her gait was more rolling than humans'.

Age: 3.2 million years

Species: *Au. afarensis*

Lucy was found in 1974 in Hadar, Ethiopia. She could walk upright, but had longer arms and shorter legs than we do.

KENNIS & KENNIS RECONSTRUCTIONS

► Leakey's find moved the cradle of humanity to Africa, but it still did not answer the question of who were the ancestors of the first humans.

SCAN DISCLOSES TWO SPECIES

Today, only a few fossils exist from the period 2-3 million years ago, in which the last hominids disappeared, and the first humans of the *Homo* lineage originated.

The so far oldest evidence of a *Homo* was a 2.3-million-year-old upper jaw from Ethiopia known as AL 666-1.

Like Leakey's OH 7, the jaw is considered a *Homo habilis*, and together, the two finds make up the first human species. Or they used to up until now.

The OH 7 fossil was in a very bad state, when discovered, the skull being crushed and wrung out of its original shape in the fossilization process, so the fragments can be assembled in different ways.

Without a clear image of the first humans, it is difficult to find the ancestor. But now, a new technology offers a solution.

Professor Fred Spoor from the University College London, England, who is an expert on 3D visualisation, has been allowed access to the OH 7, and has been digitizing the fragments in a CT scanner.

After several weeks of work, during which each individual fragment was tossed and turned, until it fitted into another fragment, Spoor assembled the fossil into its original shape. The jaw proved more primitive than those of the *Homo* lineage, whereas the skull included a 0.8 l brain - bigger than the *Homo habilis*' and resembling the smallest *Homo erectus* brains.

Spoor subsequently took a look at the AL 666-1 upper jaw, and once again, he was surprised, as the teeth resemble those of a *Homo erectus*, and so, the jaw cannot belong to an early *Homo habilis*.

Consequently, the OH 7 fossil differs so much from the AL 666-1 that they cannot possibly belong to the same species. This

66

The jaw is 0.5 million years older than the record holder, AL 666-1, and clearly more primitive

means that the two of them must have a so far unknown common ancestor, who lived 2.3 million+ years ago. None of the fossils could be from the first human species. The digital reconstructions show that East Africa was the home of several types of humans 2-3 million years ago, who not only differ in terms of brain size, but also concerning teeth adjustment to the diet. According to Fred Spoor, the AL 666-1 is an obvious ancestor of the more sophisticated *Homo erectus* and so of us, whereas Leakey's OH 7 is a dead end.

TEETH BELONGED TO A CARNIVORE

Back in his lab, Fred Spoor is not looking forward to telling the scientist behind the AL 666-1, William H. Kimbel, that the fossil is not the first human. But much to his surprise, Kimbel just nods, telling Spoor about a discovery he has just made in the Afar region of Ethiopia.

The find is a 2.8-million-year-old lower jaw with the remains of five teeth. The jaw is 0.5 million years older than the record holder, AL 666-1, and clearly more primitive than both it and the OH 7.

The new jaw's small molars reveal that its owner consumed a balanced diet, which, unlike hominids', included meat. The teeth are evidence of the shift in diet and lifestyle characterizing humans.

Combined, the features show the vague contours of a new species, which may well be the first human.

Moreover, the jaw resembles the hominid Lucy's so much that the *Homo* lineage very likely descends from the *Australopithecus afarensis*, which lived in the Afar region until only 200,000 years before the owner of the new jaw was born. Scientists think that the first human conquered a new habitat, parting from the hominids.

So, the new find links us directly with a hominid, making Lucy, an *Australopithecus afarensis*, our obvious ancestor. The next step is to find more fossilized fragments of the jaw's owner, enabling us to see the face of the first human, not just a human grin of a monkey jaw.



FAMILY TREE BREAKS UP

A new find of 3.3-million-year-old stone tools has once again stripped humans of a unique status: tool use. Combined with several other finds, there is now every indication that the differences between human species are small and few.

Much too old. That is the best way of describing a new find of stone hammers and knives. The tools are some 3.3 million years old - which means they were made 0.5 million years before the first humans originated.

Stone tools require fine motor skills and highly-developed mental capacities. The new find shows that stone tools are not reserved

to humans, as previously believed, and several other finds contribute to changing our notion of humans.

NEANDERTHALS SPOKE LIKE US

The discovery of the 3.3-million-year-old stone tools is one in a long series of finds demonstrating that the capacities of the

human species are not as unique as scientists used to think.

The traditional view of our evolution is that humans originated, when primitive hominids stood up and walked. Since then, humans evolved into a straight lineage of different species with individual physics and capacities. But all the species had those features.

Meet your family!

The brain has grown, and the body is taller. Though all members of the human race basically have the same capacities, those have been fine-tuned over the years. And so, over time we have obtained more deadly weapons, clothes on our bodies, and a sophisticated language.



Homo habilis

Where: East and South Africa
When: 2.3-1.4 million yrs ago
Height: 100-135 cm
Brain: 0.5-0.75 l
Weapons: Stones + branches
Dwelling: Where possible
Clothes: No
Diet: Plants and a little meat
Language: Possibly
Rituals: No



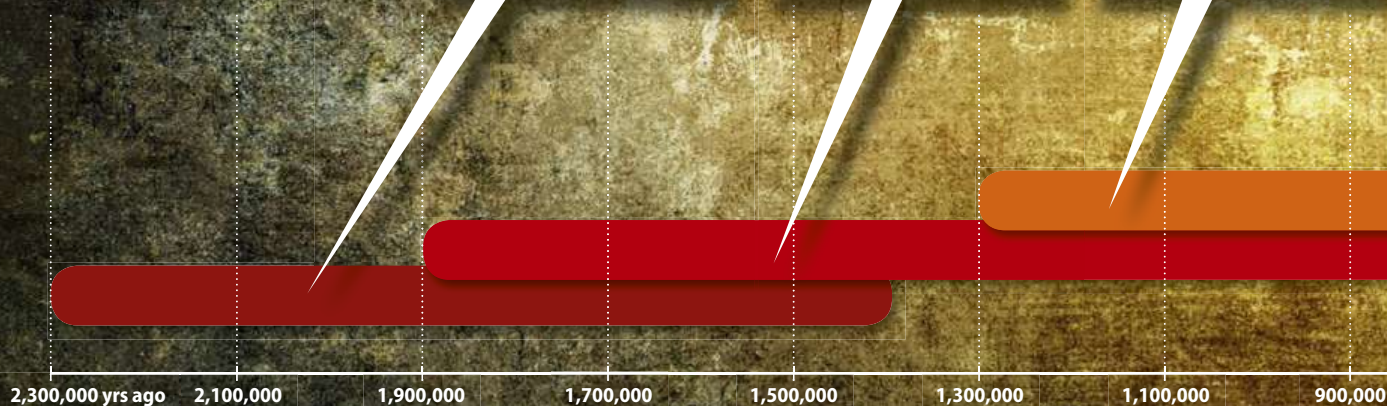
Homo erectus

Where: Asia and Africa
When: 1.9 m -150,000 yrs ago
Height: 145-185 cm
Brain: 1 l
Weapons: Stone axe
Dwelling: Caves
Clothes: Probably not
Diet: Plants and lots of meat
Language: Probably
Rituals: Patterns



Homo heidelbergensis

Where: Europe, Asia, Africa
When: 1.3 m -200,000 yrs ago
Height: 157-175 cm
Brain: 1.1-1.4 l
Weapons: Wooden spears
Dwelling: Caves and shelters
Diet: Meat and plants
Clothes: Probably animal skin
Language: Yes
Rituals: Perhaps burial



The Neanderthals have long been portrayed as slow and apathetic cavemen, but in recent years, several discoveries have revealed that the Neanderthals boasted many of the same capacities as modern man. Burial sites demonstrate that they had an idea of life after death. Jewellery bears witness of the use of abstract symbols. And genetics shows that Neanderthals had a language.

PHYSICAL DIFFERENCES NOT SO DIFFERENT AFTER ALL

In terms of physical structure, the hominids may not have been as different as scientists traditionally used to think.

In 2013, a team of scientists published five well-preserved *Homo erectus* skulls found in Dmanisi, Georgia. Their five

owners lived 1.8 million years ago, and combined, they represent three men, a woman, and a teenager.

The five definitely belonged to the same species and lived within a period of a few hundred years, but they are different in several ways. The brain size differs from 0.5 to 0.75 l, but though the size of the smallest brains are like those of hominids, the skull is more human. One of the skulls has a flat, human face with coarse teeth like those of hominids.

The skulls show that the physical differences were considerable within the same species, and if the fossils had not been found together, they

would probably have been classified as different species.

WE CAN ALL DO THE SAME

The new finds have produced a new and more complex image of the human species. The world was teeming with different humans, who all had the same basic capacities. So, although we are more sophisticated than our ancestors, humans do not have special capacities.



Homo neanderthalensis

Where: Europe and Asia Minor
When: 200,000-25,000 yrs ago
Height: 155-164 cm
Brain: 1.6 l
Weapons: Rock head spears
Dwelling: Caves and shelters
Diet: Meat and plants
Clothes: Made of animal skin
Language: Yes
Rituals: Burial



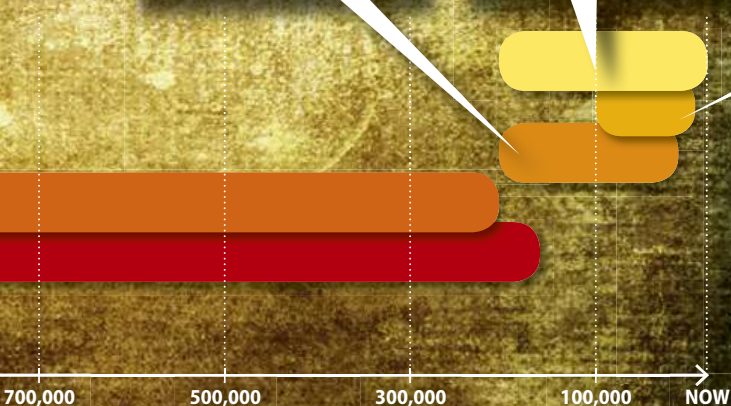
Homo sapiens

Where: All continents
When: 200,000 yrs ago - now
Height: 160-175 cm
Brain: 1.4 l
Weapons: Spears, bows/arrows
Dwelling: Caves, shelters, houses
Diet: Meat and plants
Clothes: Skin, wool, plant fibres
Language: Yes
Rituals: Burial and art



Homo floresiensis

Where: Island of Flores, Indonesia
When: 100,000-13,000 yrs ago
Height: 106 cm
Weight: 30 kg
Brain: 0.4 l
Weapons: Spears
Dwelling: Caves
Clothes: Probably not
Diet: Plants and meat
Language: Probably
Rituals: No





OUT OF AFRICA

Efficient hand weapons and a diet of meat. That was the success formula of the first explorers in the world. The *Homo erectus* human species left Africa shortly after emerging and migrated thousands of km in record time. *Homo erectus* was a hunter, and on its way through the world, new prey was easily located in unknown hunting grounds. So, the diet meant that *Homo erectus* could leave its local area.

MIKKEL JUUL-JENSEN



The five Dmanisi skulls

Homo erectus quickly left Africa

Five 1.8-million-year-old skulls discovered in Dmanisi, Georgia, reveal that *Homo erectus* left Africa quite shortly after its origin 1.9 million years ago. Some of the skulls have very primitive characteristics such as a small brain. Studies have demonstrated that the brain was long, wide, and low, i.e. the modern shape, which is not seen until the origin of *Homo erectus*.

C. P. E. ZOLLIKOFER & M. S. POISE

- Fossils or evidence of *Homo erectus* discovered here.
- Homo erectus* probably lived here.

HOMO ERECTUS LEAVES AFRICA VIA SYRIA AND LEBANON, spreading into Asia from there. According to scientists, *Homo erectus* just followed prey into new niches and regions like any other predator would do.

0.6-MILLION-YEAR-old fossils found in Algeria and Morocco show that *Homo erectus* also follows a route along the Mediterranean to Northern Africa.

1.8 MILLION YEARS ago, *Homo erectus* reaches Georgia.

One group heads for South East Asia.

GEORGIA

EAST AFRICA

HOMO ERECTUS originates in East Africa 1.9 million years ago, but already 1.8 million years ago, it has spread all the way to Indonesia.

1.8 MILLION YEARS ago, one group crosses the ocean to Java.

INDONESIA

SOUTH AFRICA

1.8-MILLION-YEAR-old *Homo erectus* discoveries in South Africa show that one group is moving south.

Homo erectus crossed the ocean

The first *Homo erectus* fossils were found on the island of Java, Indonesia, in 1891. The discovery made the scientists of the time believe that Asia was the cradle of humanity. Today, we know that *Homo erectus* originated in Africa, so it **crossed the ocean** between the islands. How remains a mystery.

Adventurer's 4 new advantages

Homo erectus was taller, smarter, and faster than its predecessors and mastered a series of new disciplines, which allowed it to leave Africa.



1. Long-distance running

The tall and slim runners' legs have grown longer, whereas the arms have become shorter. This body build allowed Homo erectus to cover long distances and follow prey out of Africa.



2. Better tools

Homo erectus develops hand axes with two sharp edges. The axe can be used for anything from chopping branches off trees to cutting meat off prey and is considered the first technological breakthrough ever.



3. Meat diet

The size of the teeth and the molecules they included reveal that Homo erectus was a hunter that consumed lots of meat. This diet is easy to travel with, as animals can be killed in the same way anywhere in the world.



4. Fire

The oldest finds of fire places show that Homo erectus controlled fire. The fires not only scared off predators, they also retrieved more energy from the food, as cooked food is easier to digest.

0.8 MILLION YEARS ago, a Homo erectus group reaches China.

CHINA

Chinese finds are more recent than African

Palaeontologists have found many Homo erectus fossils in China. These finds are **all younger, taller, and equipped with larger brains** than the African ones, supporting the idea that the species originated in Africa.

Species ended up like Hobbits

On the Indonesian Island of Flores, scientists in 2003 found fossils of a hominid, which was named Homo floresiensis. The creature, which was about 1 m tall, **lived on the island until some 13,000 years ago**. It is probably a Homo erectus, which has shrunk to miniature size over time.



Unlike previous tools, the hand axe could be used for several purposes. It is considered the world's first Swiss knife.





THE WORLD SWARMS WITH HUMAN SPECIES

The discovery of a human jaw on the ocean floor off the coast of Taiwan may add face number six to the gallery of different human species that roamed the Earth at the same time as modern man. Perhaps all of them live on in our genes.

When Taiwanese fishermen recovered their nets in the Penghu Canal 25 km off the west coast of Taiwan, they were in for a surprise, as the nets contained an old human jaw.

The discovery, which has been named Penghu 1, is a well-preserved right lower jaw with big teeth, indicating that a group of primitive humans lived in Asia. They could be an unknown species, which may have populated the region as late as 10,000 years ago.

So, the find could add a new face to the swarm of unknown human species that have appeared in recent years – humans, who lived side by side with modern man, Homo sapiens, and who have completely changed our understanding of the history of mankind.

SIX SPECIES LIVED AT THE SAME TIME

In the past 10 years, one find after the other have convinced scientists that modern man cannot always have been as alone as we are

today. Until 13,000 years ago, the world was swarming with both known and unknown human species.

On the Indonesian island of Flores, scientists in 2003 found the fossils of an unknown human species, Homo floresiensis, that probably did not become extinct until 13,000 years ago. In 2010, a team of geneticists discovered yet another new species by sequencing a bone from a museum. The species, which was named Denisova, lived in Asia 41,000 years ago. In 2012, scientists discovered a third new species, the Red Deer Cave People, which lived in Southern China up until 10,000 years ago.

The new species have even been accompanied by known species, which probably lived longer than we used to believe. New finds indicate that Homo erectus roamed Asia until 35,000 years ago, whereas the Neanderthals were in Europe until 25,000 years ago.

The species to which the owner of the

Taiwanese jaw belonged probably originated in Asia 400,000 years ago and did not disappear until 10,000 years ago.

CHEMISTRY REVEALS AGE OF JAW

The jaw was originally found in 2008, but it was not known until a local collector bought it and took it to the Natural History Museum of Taiwan, where a team of scientists headed by palaeoanthropologist Chun-Hsiang Chang studied it.

Other fossils, which have also been retrieved from the ocean floor, are hard to date, as scientists usually date fossils based on the age of the soil layers, in which they were found. To date the jaw, scientists measured the amount of different substances, comparing the data to the contents of hyena fossils also found on the floor of the Penghu Canal.

The chemistry of the jaw is much like the animals', and as the hyena species ►

Agriculture spurs population growth

Approximately 13,000 years ago, humans began to tame nature by breeding specific plants and animals. Farming makes the population grow explosively and marks the beginning of the greatest radical change for humans ever.

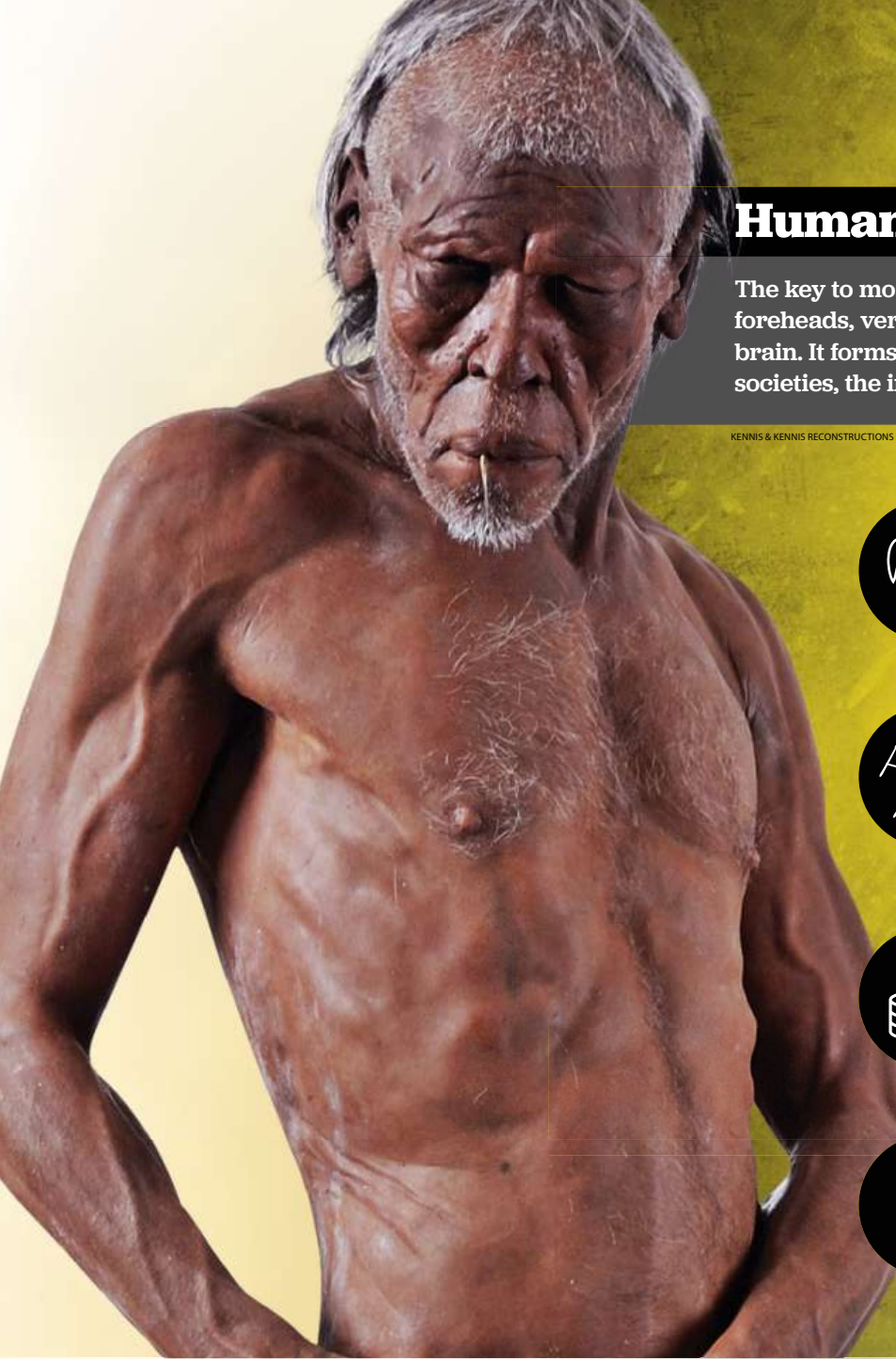
Agriculture means surplus of food, allowing the support of a larger population. So, more people

settle permanently, producing more children and causing the population to grow. Though child mortality is unchanged or even slightly higher than before, the population quickly grows from tens of thousands to millions of people.

The rapid population growth quickly turns villages into towns and entire civilisations.



Sheep and pigs are among the first animals to be domesticated, when people settle to be farmers.



Humans conquer the world

The key to modern man's success is located in our high foreheads, vertical temples, and arched skulls: a complex brain. It forms the basis of a new way of organising societies, the invention of tools, and an explosion of art.

KENNIS & KENNIS RECONSTRUCTIONS



Specialised tools

For the first time, modern humans make tools for making other tools. The new tools, which are more elaborate and made of new materials such as bone, allow us to utilise the natural resources more efficiently.



Art and symbols

An explosion of creativity follows modern humanity's arrival in Europe, where figurines, cave paintings, and jewellery testify to a new, creative type of intelligence and a brand new understanding of abstract symbols and ideas.



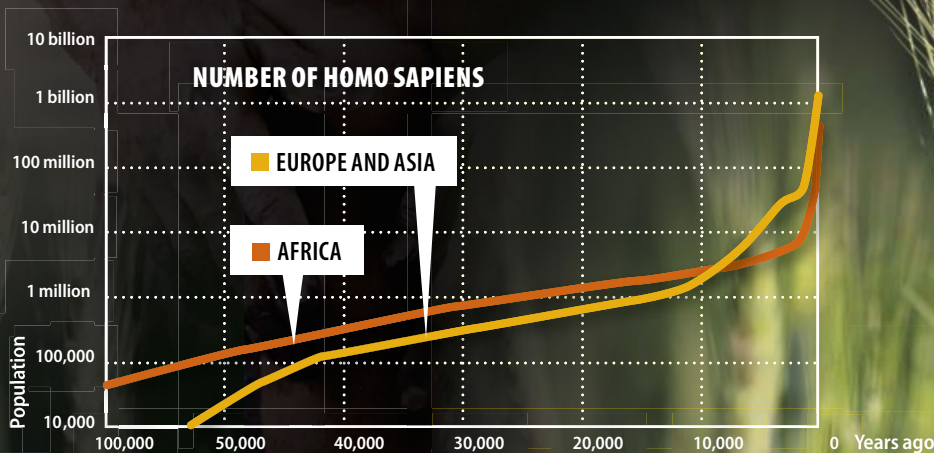
Trade

Modern humans are the first to exchange goods across long distances. Trade is a new way of communicating and socialising with others, demonstrating that we are able to cope with complex social contexts.



Farming and animals

Modern humans grow plants and domesticate animals. The first settled peasants live in the Middle East, but agriculture also originates separately in Asia, America, and Africa, displacing hunter-gatherers.





► originated 400,000 years ago at the earliest and did not fully populate the region near Taiwan until 10-170,000 years ago, the jaw probably dates back from the last period.

But who was the owner of the jaw? Scientists cautiously suggest a 400,000-year-old fossil discovered about 1,000 km away in the Chinese city of Hexian. The two fossils may represent an unknown hominid.

WE MATED WITH DIFFERENT SPECIES

The owner of the jaw may be related to the mysterious Denisova, which we only know from DNA extracted from a 41,000-year-old fossilised finger fragment found in the Denisova cave in the Altai Mountains.

The Denisova is the first hominid found only based on DNA. Scientists' knowledge about the species is limited, as fossils are sparse, but they know that it is closely related to the Neanderthal, and that the species lived in major parts of Asia 125,000-40,000 years ago.

The Denisova is interesting, as it has modern descendants. DNA analyses have shown that native Americans, East Asians, and people from Papua New Guinea and in Australia all include Denisovan DNA. So, they must be the results of a sexual encounter between Homo sapiens and the Denisova.

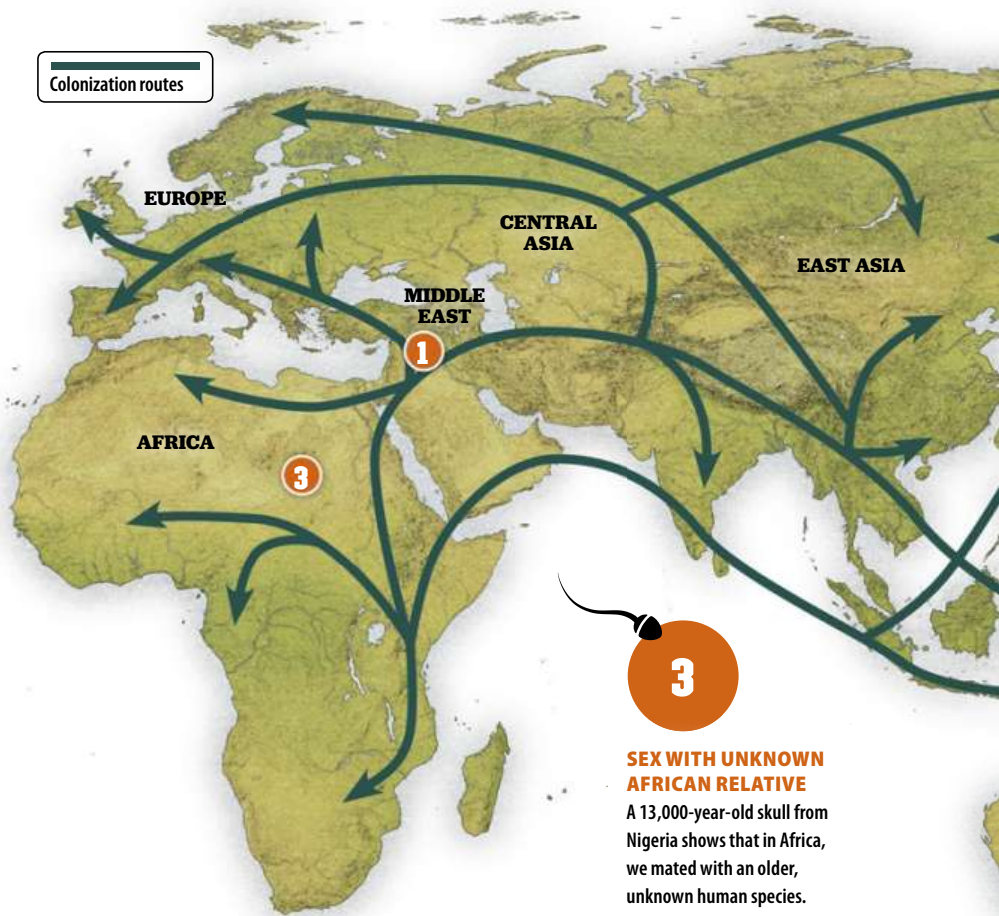
The Denisova DNA included in modern people is very different from the Siberian DNA. The Denisovas that our ancestors mated with are only remotely related to the Siberian Denisovas, which means the Denisovas were pretty widespread.

So, until 10,000 years ago, we were living side by side with at least six other human species and mated with at least three of them. If the Taiwanese jaw belonged to a Denisova, scientists can finally find out what it looked like.

Humans colonise the planet in 60,000 years

DNA sequencing of skeleton finds and modern people have outlined the routes that modern man followed when he conquered the continents. But humans were not alone on their journey. En route, they mated with several other species.

MIKKEL JUUL JENSEN



The Taiwanese jaw, that may have belonged to an unknown species, was retrieved from the ocean floor by fishermen.

CREATIVE COMMONS

AFRICA

Pioneers sailed out of Africa

70,000 YEARS AGO

The first modern humans followed the coast and crossed a narrow strait between Africa and Yemen. 70,000 years ago, the sea level was lower, so the strait was only a few km wide. The emigrants probably built a simple raft and stopped by small, dry islands on the way.

AUSTRALIA

Emigrants walk along the coast

50,000 YEARS AGO

In very short time, the first emigrants spread along the coast and across India, only to arrive in Australia 50,000 years ago; a pristine continent with peculiar animals. En route, they probably built small settlements, but the only existing evidence is skeletons in Mungo, Australia.



1

HOT DATE IN THE MIDDLE EAST

Geneticists have sequenced the DNA of the Neanderthals based on DNA from in old bones. The sequencing shows that we mated with Neanderthals several times. The first time was in the Middle East 50-60,000 years ago.

KENNEDY & KENNIS RECONSTRUCTIONS

Homo neanderthalensis

2

EVEN MORE MIXING OF SPECIES

Australian Aboriginals have 3-6 % Denisovan in their DNA, so the ancestors of the Aboriginals must have mated with the foreign species.

SOUTH EAST ASIA

2

AUSTRALIA

AMERICA

Homo floresiensis

KENNEDY & KENNIS RECONSTRUCTIONS

Homo sapiens

EUROPE

Three cultures roam Europe

45,000 YEARS AGO

New studies have shown that Europe was populated in three rounds. The first were hunter-gatherers, who followed the Danube river from the Black Sea into Europe 45,000 years ago. Then, 8,500 years ago, a Turkish people spread across Southern Europe, followed by Russian nomads 4,000 years later.

ASIA

Europeans live in Asia

35,000 YEARS AGO

DNA has shown that the peoples living in Europe and major parts of Asia are genetically the same. So 35,000 years ago, Central Asia was populated by the same Middle-eastern people who migrated to Europe. Not until 2,000 years ago were these people replaced by modern Asians.

AMERICA

Ice-free passage to America

16,000 YEARS AGO

America was the last continent to be populated. It happened at least 16,000 years ago via an ice-free corridor between Siberia and Alaska. The first humans followed the coast all the way to the southern point of South America. The Arctic people arrived later and never ventured south.

KENNEDY & KENNIS RECONSTRUCTIONS



FUTURE HUMANS WILL BE COUCH POTATOES

In recent years, a series of studies have revealed that humans are evolving faster than ever. We can look forward to smaller brains and weaker muscles.

Today, humans number 7 billion individuals and we're no doubt a great evolutionary success. We are the most intelligent creatures that ever roamed the Earth. And thanks to our complex brains, we conquered all regions of the world, defeated deadly diseases, and wiped out our enemies. But the development is not over, as we are still evolving at a furious speed.

GENES ADJUST TO THE WORLD

Human genes are constantly affected by the world, in which we live. The body does not invent new genes, but the frequency of a certain gene variant can be increased, if it improves a people's survival chances. The survivors pass the gene on to their children, while the ones without the gene go extinct.

In the Himalaya, where the air is thin, people have a gene variant that is not found anywhere else. The gene reduces the amount of haemoglobin in the blood, making it easier to live in the oxygen-poor mountain region. The gene is from an earlier human species, but has only been vital in the Himalaya, and so, it has disappeared in all other places.

Similar mechanisms have been at play in Europe. Only 8,000 years ago, light skin did not exist in Europe, but today, a gene variant producing light skin exists in 95 % of the population of some European countries.

The light skin has been an advantage under Northern skies, as it will easier retain UV rays and so vitamin D from the sparse amount of sunlight.

Disease is also a strong evolutionary force. In Africa, a specific blood gene variant known as Duffy has recently gained ground, which protects against a type of malaria by the name of vivax. In regions where vivax malaria is common, 90 % of the people have the Duffy gene.

MORE PEOPLE, MORE MUTATIONS

Humans do not just adjust to the surroundings. Gene mutations involve an element of coincidence. In Mongolia, the population has long used mare milk without developing the ability to digest milk, as the genetic mutation has not originated. But the more people, the better the chances of the mutation developing.

The peoples of the world have developed individual gene variants, which are expressed in terms of physical characteristics.

SHUTTERSTOCK



Small brains and poor vision

Modern humans are quite different from the people diverging from the hominids three million years ago. But the evolution continues. Future humans will be tall and weak.

In 2007, scientists proved that human genes have changed more during the past 20,000 years than in the past two million years combined due to the population growth produced by agriculture, by which the number of people quickly went from thousands to millions.

Population experts predict that by the end of the century, nearly 10 billion humans will walk the Earth together, so our genes will undoubtedly change even more over time.

OUR BRAINS ARE SHRINKING

At present, the two major influences are technology and medication. They will also affect us in the future, and scientists are observing evidence that we are growing older and weaker.

Anthropologist Maciej Henneberg, who was born in Poland, has documented a reduction of brain volume in European women from 1.5 l to 1.24 l and a similar development in men during the past 10,000 years. The reduction happened 36 times faster than the growth of the past 800,000 years.

Technology has probably taken quite a load off the brain, and as the brain is very energy-consuming, it makes sense to shrink it. If so, the big brain that originally defined us will soon be gone. **SCI**

● Shrinking brain

Over the past 10,000 years, the brains of both men and women have shrunk 18 %, probably because technology has taken over some of the human brain's functions. As the brain is extremely energy-consuming, the body will automatically shrink it to economize on resources.

● Older population

As we gradually get a better diet, fewer diseases, and more medication, more of us will remain healthy and well-functioning in old age. The average life expectancy will rise, and many will live to be 100+ years old.

● The body loses muscle mass

Modern people have weaker muscles and poorer vision than early humans. This development will continue, as we will get more aids such as glasses and robots, reducing the amount of and need to carry out manual work.

● Dark hair

Some physical features such as specific hair and skin colours are recessive, requiring that you have a copy of a certain gene variant from both parents. Today, we travel the world and mate with foreign peoples. Although gene variants such as red hair and blue eyes will still exist in the human gene pool, more and more people will be brown-eyed and black-haired.

● Humans grow taller

In recent centuries, humans have become still taller, not because special gene variants have gained ground, but because we have easier access to food and so are not curbed by lack of energy.

● Smaller teeth

The modern diet is easy to digest and does not require powerful teeth. Consequently, our teeth and chewing apparatus will be even smaller than they are today, and the wisdom teeth will disappear altogether.

● Improved immune system

We live closer to each other now than ever before, allowing diseases a good chance of developing, and so, epidemics will be more common in the future. The diseases will challenge our immune systems, meaning that beneficial gene variants will quickly gain ground, resulting in people with stronger immune systems than today.

● No new human species

Modern people live too close to each other for isolated groups to evolve into their own species, such as *Homo floresiensis*. But new human species could originate, if humans established isolated colonies in space.



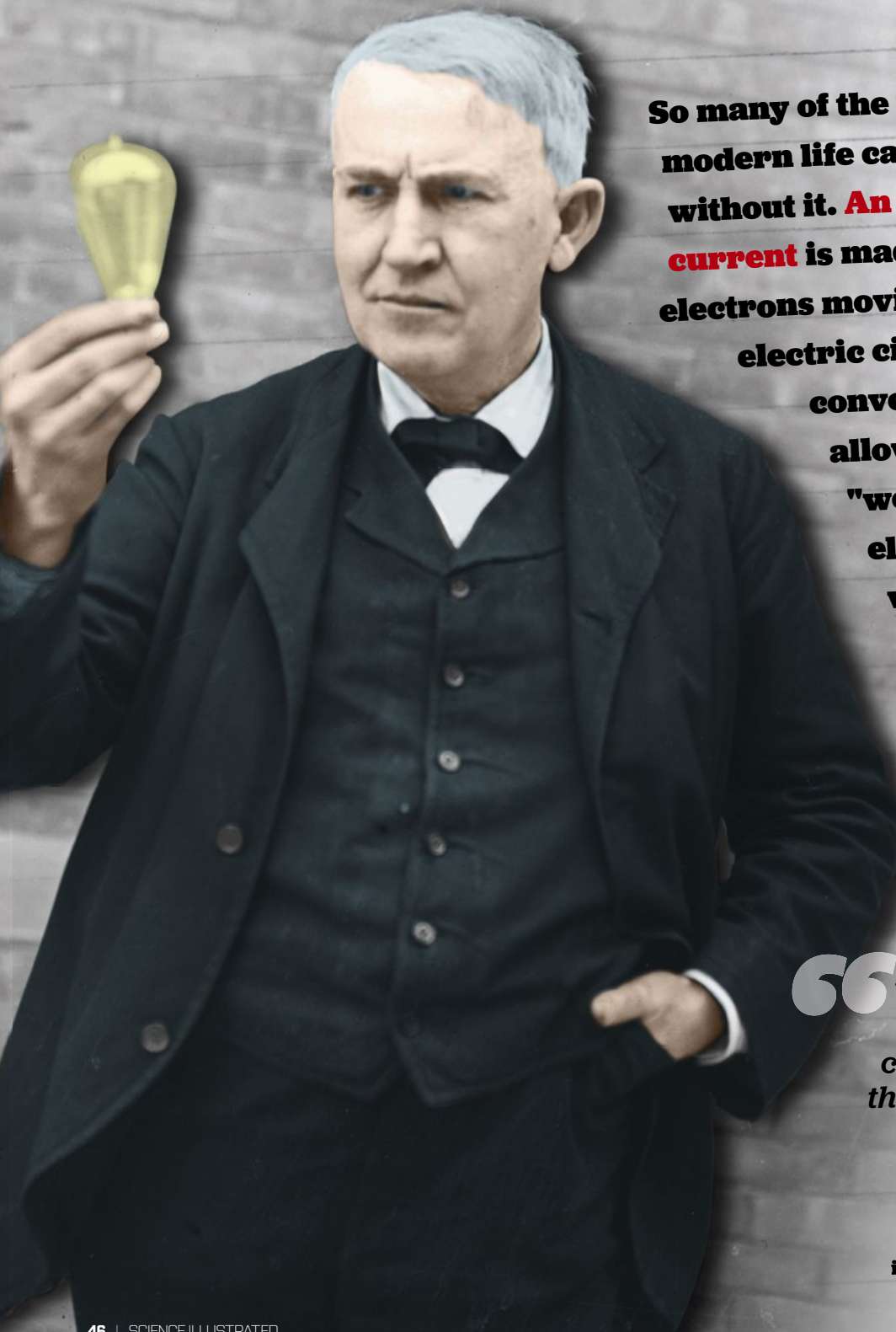


Electricity

Spend 10 minutes on the next four pages and learn more about fundamental science.



By Mikkel Meister



So many of the tools of modern life cannot be used without it. **An electric current is made up of electrons moving about an electric circuit. It conveys energy and allows systems to "work". But electricity is also what keeps us remembering, thinking, and even moving.**

“We will make electricity so cheap that only the rich will burn candles.”

Thomas Alva Edison, power pioneer and inventor of the world's first power utility

1880

American inventor **Thomas A. Edison** patents the electric light bulb. Edison didn't invent the soon-to-be ubiquitous globe, but his version has become the symbol of electricity, as it played a central role in the efforts to bring cheap power to the people from the world's first power utility.

Power plant electricity is known as **alternating current**, as the generators of the plant make the current change direction - or alternate.

GETTY IMAGES

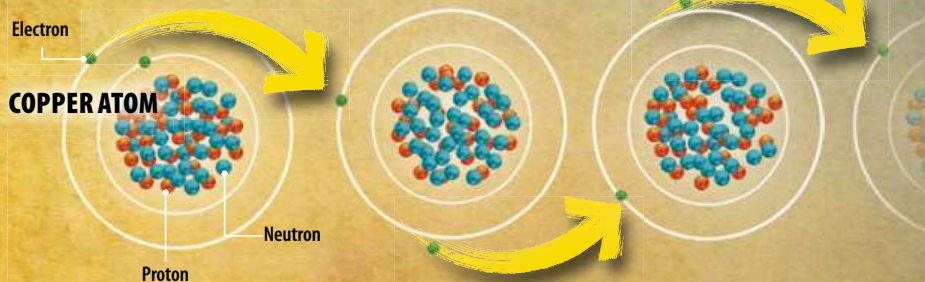


Moving electrons create a current

A current is negative electric charges – electrons – flowing about an electric circuit like the water in a river. The electrons carry the energy that the circuit needs to function. The circuit can be described by three physical units that make up **OHM'S LAW**:

Energy jumps

In electric wiring, the nuclei of copper atoms do not move, but rather the electrons jump from atom to atom.



Resistance - OHMS

How easy or difficult it is for the current to flow.

Voltage - VOLTS

The force making the electrons move about an electric circuit.

$$V = R \times I$$

Electric current - AMPERES

The number of electrons moved per unit of time.

Electricity powers phone

An internal circuit provides a smartphone with energy.

1 When the battery is fully charged, electrons trickle into the circuit from the battery's **NEGATIVE POLE**.

2 **VOLTAGE** means that a current flows from a place with lots of electrons (minus) to a place with a few (plus).

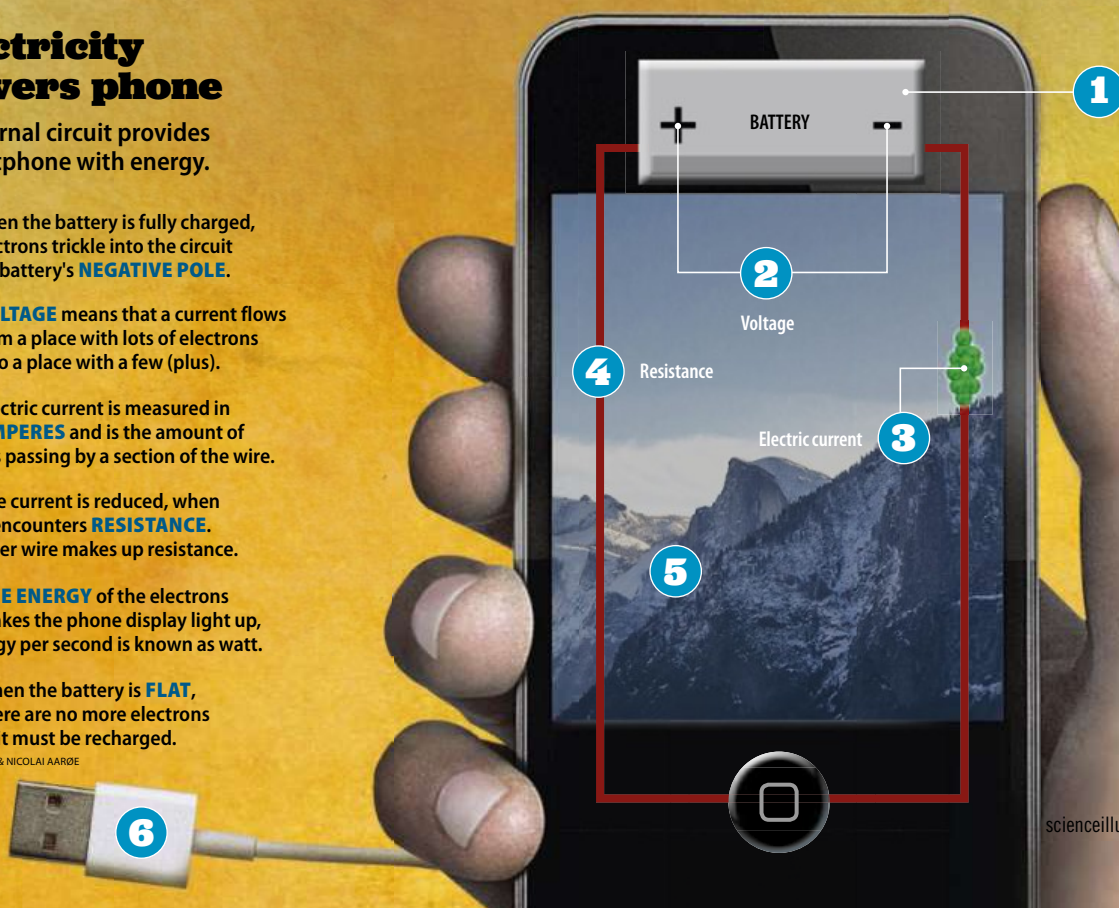
3 Electric current is measured in **AMPERES** and is the amount of electrons passing by a section of the wire.

4 The current is reduced, when it encounters **RESISTANCE**. The copper wire makes up resistance.

5 **THE ENERGY** of the electrons makes the phone display light up, etc. Energy per second is known as watt.

6 When the battery is **FLAT**, there are no more electrons left, and it must be recharged.

SHUTTERSTOCK & NICOLAI AARDE



Did you know that:

due to special stomach organs,

the electric eel

can produce an electric shock of 600 volts and up to one ampere for two milliseconds? The eel uses the shocks to paralyse its prey or defend itself against other predators.



Your brain is an electric machine

As you are reading this article, a cascade of electric impulses keep your brain and limbs going. The human brain and nervous system are made up of billions of neurons – nerve cells – that control anything from vision and learning to muscular movements. The neurons communicate with each other, issuing orders by shooting off tiny electric impulses at a very high speed.

SHUTTERSTOCK & NICOLAI AARDE

3 The impulse travels to the end of the axon, where the electric impulse encounters a gap – a synapse. A **NEURO-TRANSMITTER** is liberated, seeing to it that the message reaches the dendrite of the neighbouring neuron and is passed on to the brain.

1 The cell body uses the long cord of the neuron – an axon – to fire off **ELECTRIC IMPULSES** towards other cells. The part of the neuron that receives impulses from a neuron and sends them on to another one, is known as a dendrite.

2 A neuron at rest can produce an **ELECTRIC CHARGE** in itself, making it negatively charged compared to its surroundings. Other neurons can reduce the difference of charge by firing a nerve impulse at the neuron. The impulse can travel at over 360 km/h.

Synapse

End of axon

Nerve impulse

Dendrite

Dendrite

CELL BODY



All metal atoms have electrons in their outer shells, which would like to escape. That is the quality that makes metals electrically conductive. The best conductors are silver, copper, and gold.

GETTY IMAGES

4

Millions of electric impulses are constantly moving about the human brain's network of neurons. Some neurons, known as **SENSORY**, specialise in sending impulses from eyes, ears, and skin through the central nervous system to the brain, where they are processed.



5

Other neurons, known as **MOTOR NEURONS**, send electric impulses in the opposite direction.

They send messages from the brain to the muscles to lift the right leg or make the left arm try to catch a ball.

MIKKEL JUUL JENSEN

Test (did you pay attention?)

- 1 Which atom particles cause an electric current to flow through a wire?
- 2 What is the unit of electric current?
- 3 What happens to the current, when the resistance of the circuit increases?



ANSWERS: 1: Electrons, 2: Ampere, 3: It is reduced.

From amber to DNA wire

600 BC

By rubbing amber against animal skins, the **Ancient Greeks** discover static electricity. In Greek, the word "electron" means amber.

SHUTTERSTOCK



>> 1752

According to American inventor and President **Benjamin Franklin**, lightning is the electric current of nature. Legend has it he tested this by flying a kite during a thunderstorm.

1800

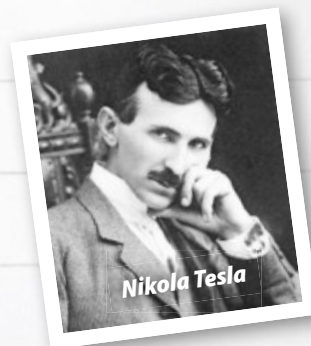
Italian physicist **Alessandro Volta** invents the voltaic pile of copper and zinc discs. The pile is the precursor of the modern battery.

>>

1880

A war rages between **Edison's** direct current and **Tesla's** alternating current. The latter wins, as it is easier to get to consumers' homes.

GETTY IMAGES



1947

Physicists **John Bardeen**, **Walter Brattain**, and **William Shockley** invent the transistor – an electronic device functioning as a small switch. It is a fundamental part of a computer.

SHUTTERSTOCK



>> 1971

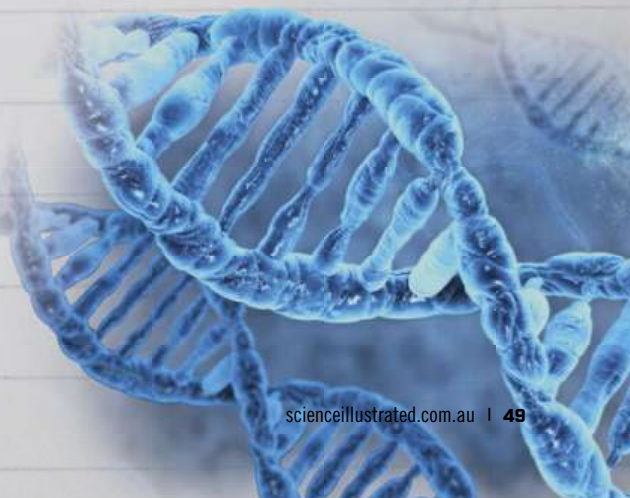
Leon Chua coins the term memristor – an electronic device that adjusts resistance according to the current flowing through it and the direction of the current.

2015 DNA conducts electricity

Israeli scientists create a DNA wire that conducts electricity. For years, the scientists studied DNA molecules, which can be folded into many different shapes, allowing the construction of much more compact computers. Scientists have invented a method enabling them to measure the amperage of DNA to be some 10-100 picoamperes – or 10-100 billionths of an ampere. This could be a breakthrough in molecular electronics.

The long DNA molecules conduct electricity and can be densely packed.

SHUTTERSTOCK



THE WORLD'S BIGGEST ACCELERATOR REAWAKENS!

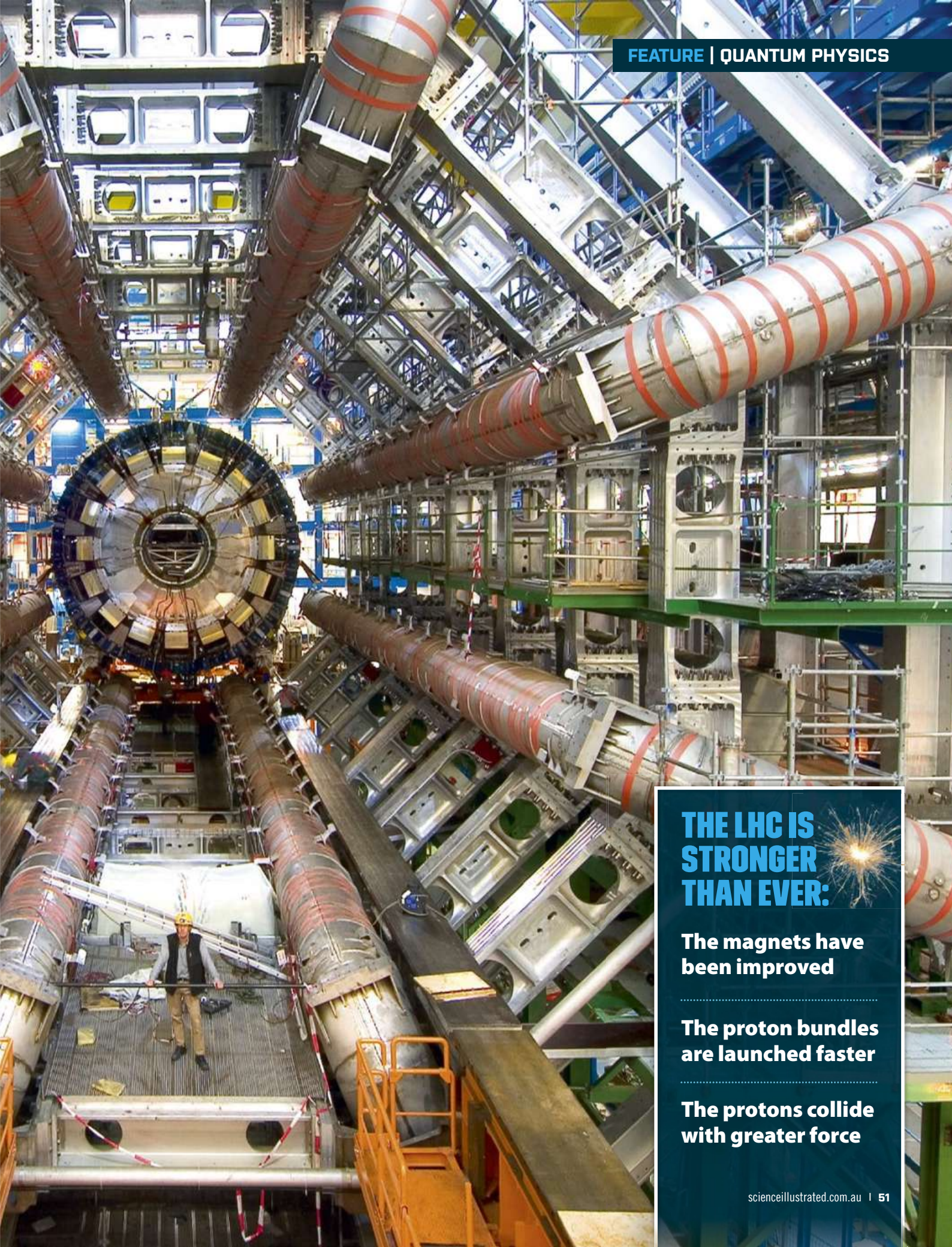
LHC

Following the discovery of the Higgs boson in 2012, physicists have reactivated the huge LHC particle accelerator in Geneva. The giant is now colliding protons at 1.5+ times the previous force to solve one of the mysteries of particle physics: supersymmetry.

By Anne Lykke and Rolf Haugaard Nielsen

MAXIMILIEN BRICE/CERN





THE LHC IS STRONGER THAN EVER:



The magnets have been improved

The proton bundles are launched faster

The protons collide with greater force

LARGE

The accelerator's first name is Large, as it is the world's largest, with a 27 km circumference. Nevertheless, protons loop the LHC 11,245 times per second, travelling at 99.9999991% the speed of light.

Can you see it?" Rosario Principe asks. "Perhaps," I say, closing one eye like a rifleman trying to take aim. I am looking at a 16-m-long superconducting magnet, which bends just 9 mm along its entire length. Principe, a CERN project engineer, looks slightly disappointed as he moves on. Science Illustrated is visiting the European Organisation for Nuclear Research, CERN, and at the moment, we are

in the Large Magnet Facility, whose machines look a little old. But appearances are deceptive: The best superconducting magnets in the world are made here.

The accurate 9 mm bend of the magnet is produced in a huge press for a single purpose: When all the magnets are combined, they make up a 27 km circle – the accurate circumference of the world's biggest particle accelerator, the Large Hadron Collider (LHC). The size is key, as the protons speeding through the magnets boast such high energy levels that not even the most powerful supercharging magnets can bend the particles in a tighter curve.

In 2012, physicists discovered the Higgs boson using the LHC. The next step is finding supersymmetric particles, also known as twin particles. But that mission requires even more power than the LHC was able to muster in 2009-2013, physicists only dared to use a collision energy of 8 TeV due to a severe

accident in 2008, when the accelerator was readied. An electrical connection between two supercharging magnets failed, so too much electrical resistance was produced in the metal. The magnets lost their supercharging powers, overheated in a split second, and exploded into a cloud of six tonnes of helium. The repair took one year and cost \$52 million. Subsequently, the LHC operated at 8 TeV.

Now, engineers have retrofitted the LHC with 10,000 new electric couplings between the magnets, and introduced more safety systems to avoid accidents, and the LHC is constantly monitored.

"The security guard can deactivate the accelerator in a jiffy via an old-fashioned, mechanical relay. If anything goes wrong, we do not want to depend on software and computer technology," says CERN physicist Sune Jakobsen.

Early this year, the LHC was reactivated, and in May, the giant proved that it can produce collisions at 13 TeV.

UPGRADE PRODUCED MORE POWER

Originally, the LHC was designed to collide protons at 14 trillion electron volts (TeV). In comparison, an ordinary AA battery can accelerate a proton to an energy level of 1.5 eV. But in the first round of tests in 2009-2013, physicists only dared to use a collision energy of 8 TeV due to a severe

HUGE NETWORK SECURES DATA

The smell of rice, roast chicken, and freshly made pizza mixes with the sound of loud voices. Lunch time in the CERN cafeteria is chaotic. Physicists and engineers from 100+ countries must be fed within a few hours, and

UNIVERSAL BUILDING BLOCKS HAVE INVISIBLE TWINS

Anything in the universe – from spikes to stars – consists of 12 building blocks known as **matter particles** glued together by **force carrier** particles. But something is missing, and the LHC is going to try to find the invisible matter, which probably consists of huge twins of known particles. The existence of twin particles has not yet been proven.

MATTER PARTICLES

	Electron	Electron neutrino	Up quark	Down quark	Muon	Muon neutrino	Charm quark	Strange quark	Tau particle
	Has a negative electric charge. It exists freely or bound in atoms.	Is uncharged and has very limited mass. Exists in connection with radioactivity.	Ordinary matter consists of up and down quarks plus electrons. A quark is never alone.	Protons consist of 1 down and 2 up quarks, neutrons of 2 down and 1 up quark.	Resembles the electron, but is 300 times heavier and radioactively unstable.	Resembles the electron neutrino, but it is slightly heavier, though very light.	Weights three times as much as a proton and has a positive electric charge.	Has a negative electric charge.	Is 3,500 times heavier than the electron and has a very short life.
Elementary particles (visible)									
Twin particles (invisible)									
	Selectron	Electrons neutrino	Sup quark	Sdown quark	Smuon	Muon sneutrino	Scharm quark	Strange quark	Stau particle

NOTE: Scales are not correct.



At CERN's magnet factory, 16-m-long magnets are built, whose powerful magnetic fields make particles collide.

everybody tries to avoid head-on collisions, as they walk about each other with their trays.

The scenario is just like what is going on 100 m below the cafeteria at the heart of the LHC, where protons collide. Like in the cafeteria, there are only a few proton collisions, though in theory, there could be more. That is so, because at the atomic level, the distance between protons is huge, though they are packed as densely as

possible. Indeed, only 1 % of the protons of the experiments collide. Nevertheless, there are 1 billion collisions per second.

The accelerator is equipped with four huge detectors. The smallest one weighs 5,600 t – or the equivalent of 16 fully fuelled Boeing 777 planes. The detectors cannot store all the collisions for scientists to analyse at a later point in search of the unknown twin particles.

The computer can only save 1,000 events per second of a total of one billion. Moreover, the vast majority of collisions produce known, “boring” particles such as photons and electrons. So, the challenge consists in developing electronics and software that can select the interesting collisions, which produce unusual particles. The method involves looking at the decay products and calculating backwards.

It can be compared to the computer spotting the remains of two mechanical alarm clocks, that have been collided. Fragments are littered across the floor, but by looking at the locations of the fragments, physicists can calculate backwards and find out what the alarm clocks looked like before the collision. The same method was used by scientists to discover the Higgs boson in 2012.

“You will never see a Higgs. Many people think that we have seen Higgs. In other words, Higgs is an amazing, red Ferrari in between all the boring cars. But we have only seen fragments, which told us that there was a Ferrari,” says particle physicist André D. T. Mendes, who was partly responsible for proving the existence of Higgs.

LHC TO REVEAL TWIN PARTICLES

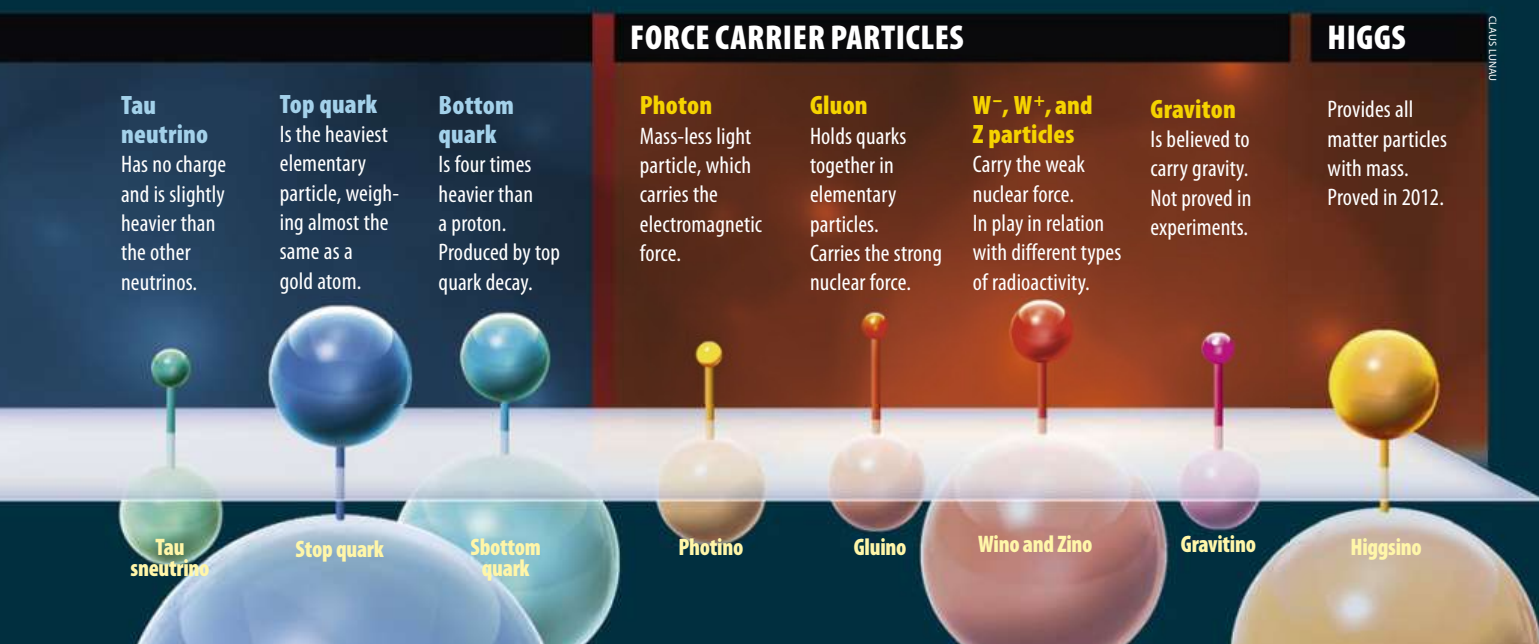
The Higgs boson plays a very special role, as all other particles get their mass by binding to Higgs. The stronger the bond, the heavier the particle. But even with the discovery of

the Higgs boson, physicists are still facing a huge challenge: proving a theory which also comprises gravity.

Right now, physicists base their work on the standard model, which describes all

elementary particles and three powers of nature: the weak nuclear force, the strong nuclear force, and the electromagnetic force. But the standard model cannot explain gravity, and so, we need a supplement – new physics – that reaches beyond the standard model. Unknown particles, whose existence can only be revealed at extremely high energy levels, may be the solution. ►

WE CAN NEITHER SEE NOR FEEL TWIN PARTICLES



HADRON

The accelerator's middle name is Hadron, because it accelerates hadrons - which are stable, electrically charged particles. These characteristics are important for the LHC's magnets being able to push and pull the particles.

TWINS MUST BE OUT THERE

One of the LHC's four detectors is known as ATLAS. The detector is controlled from a large control room, where a few handfuls of technicians and physicists are constantly staring at a series of huge displays indicating the status of each individual part of the detector. The technicians monitor the system to ensure that everything is okay. In most displays, the units are green: The accelerator is fit for fight.

According to theorists, supersymmetry, - that all particles have unknown twins - constitutes the way to "patch up" the standard model. One of the strongest indications that twin particles or something similar must exist can be observed in the galaxies. In many places, the outermost stars rotate faster than they should according to Newton's laws, which say that gravity depends on the distance to the mass. A star far away from the centre of the galaxy is held so loosely by the visible mass that it ought to be flung away.

In other words, the galaxies should spin themselves to pieces, as there is not enough matter to hold them together. But if physicists assume that invisible twin particles exist, they are suddenly able to explain the behaviour of the galaxies. Astronomers' observations of the universe indicate that there must be almost five times as much matter in the universe as we can see, and that matter could be twin particles. According to the theory, the twins are heavy, invisible, and hardly react with visible matter. ►

THE LHC HAS BECOME MORE ENERGETIC

In the LHC upgrade, the energy of the proton collisions has been increased from 8 to 13 TeV. That is the highest energy ever produced in an accelerator. Moreover, many more collisions take place than in previous experiments.

ELECTRONICS HANDLE RADIATION

The orbiting protons emit radiation, and the electronics need to be able to handle that. So, more than **400,000 electronics tests** have been carried out. In addition, the LHC is equipped with a system of tunnels and buffers that can absorb, divert, and dump unstable proton beams.

RENOVATED COOLING SYSTEM

Liquid helium cools the magnets to a temperature of **minus 271.3 degrees C**, making them even better at conducting electricity. The cooling system has been upgraded, so it is now safer.

27,000 NEW COMPONENTS

The machine must divert the electric current of 11,000 amps fast, if the cooling fails. **The current** is so powerful that it can burn all electrical connections. Consequently, engineers have attached 27,000 new copper components to the magnets, reinforcing the electrical connections.

NARROWER PROTON ORBITS

Protons circulate in different directions in two tubes. The protons are packed into a few-cm-long and 1-mm-thick bundles. When a bundle approaches a collision point, it is compressed even further to one third of the thickness of a hair, **increasing the chances of collisions** with the oppositely directed beam.

IMPROVED VACUUM

The accelerator tubes have been completely emptied of air and molecules, so the protons will only collide with each other. The inside of the accelerator has been lined with a special **new material**, which prevents the positively charged protons from detaching negatively charged electrons from the wall, destroying the ultra-high vacuum.

MORE POWERFUL FIELDS

If a bundle of protons gets slightly off course in the collision tube, the magnets will nudge the bundle back to the centre. A **more powerful magnetic field** sees to it that the protons remain together, obtaining more energy than previously.

IMPROVED DETECTORS

The accelerator is equipped with **four huge detectors** the size of country churches, which have all been improved. The ATLAS and CMS detectors have been particularly optimised to analyse and store even more proton-proton collisions.



The CMS detector is 21 m long and weighs 12,500 t.

DANIEL DOMINGUEZ/CERN & ALBERT EISEN

HIGHER ENERGY

The LHC is colliding protons at record high energy levels of **13 trillion electron volts (TeV)** as compared to 8 TeV in previous experiments. 1 eV is the kinetic energy that an electron gets, when accelerated by a voltage of 1 volt.

DENSELY PACKED PROTON BUNDLES

Proton bundles are now circulated at **25 nanosecond** intervals, corresponding to 7 metres. Previously, the distance between bundles was twice as long. The bundles are also more densely packed than they used to, producing more collisions and increasing the collision rate from 600 million collisions per second to 1+ billion collisions per second.

NEW POWERFUL MAGNETS

18 of the LHC's 1,232 superconducting magnets have been replaced by new ones, and engineers have checked all magnets for errors. One single error may mean that electricity accumulates to blow up the LHC. New safety systems divert the energy away from the magnets, so they will not break down.

HIGHER VOLTAGE

Generators pump energy into the **circulating protons** by means of radio waves. The generators now operate at a higher voltage, so more energy can be pumped into the protons.

COLLIDER

The surname Collider is due to the LHC colliding particles to produce new ones. The energy of each proton beam corresponds to a 400 t train moving at a speed of 150 km/h.

DATA STORED ALL OVER THE WORLD

But before physicists can analyse the LHC data and perhaps discover twin matter, they have a problem: The huge amounts of data produced in LHC experiments must be saved. In CERN's big computer centre, the noise is deafening, and the heat immediately makes you sweat. The rows of computers and servers seem endless, as they flash their red and blue light. CERN holds a few hundred petabytes of data combined. One petabyte is the maximum data that can be stored by some 7,800 of the most powerful iPhone 6 smartphones. And each new experiment adds millions of bytes to the huge data bank. Nevertheless, the research institution cannot store all the information itself, so it has established a huge intranet, in which 100+ research institutions throughout the

world share their computer capacity and store some of the data. Everything is saved in two places far away from each other, such as in Europe and Asia, to have backup. The intranet itself is connected by physical cables, which involves problems:

"Cables have been cut by fishing boats, and we have been hit by tornadoes, earthquakes, and other natural disasters, leaving some data centres inaccessible," says IT employee Jamie Shiers.

THE LHC IS HARD TO ACCESS

A blood-stained eye is lying on the floor – cut out of the head of a CERN physicist. That is how the main character of Dan Brown's Angels and Demons novel discovers that somebody has forced an entry into the underground Swiss facility. In the book, an iris scan is required to gain access to the LHC, but in real life, the entry requirements are even stricter. First, the CERN employee must scan his personal radioactivity metre at the door allowing access to the underground facility. The system issues a warning, if the person is about to exceed his annual dose. The scan opens a hatch to a key rack. The door can now be unlocked, and in the chamber behind the door, several sensors register whether the employee is alone and if he is entitled to enter, and an iris scanner confirms the person's identity. If everything is okay, an electronic voice says: "You have been identified", and the exit door of the chamber opens. Subsequently, the employee can take a lift 100 m into the ground to reach the facility. As long as a key is missing on the rack, the

system is locked, and the LHC cannot be activated, until there is nobody left below the ground. So, it is vital to remember to place the key back on the rack, says CERN engineer Lars Jensen.

"People have brought keys home by mistake, but you will certainly not be popular, if you stop hundreds of scientists from securing new data."

TWO SETS OF EYES ON EXPERIMENTS

"What would you do, if your doctor tells you that you only have another 60 days left to live," Mendes asks.

LACK OF ENERGY WILL REVEAL TWINS

The twin particles disappear without a trace, if the LHC produces them. But physicists can deduce their existence by taking a look at the new particles and at the energy "account" after the collisions.

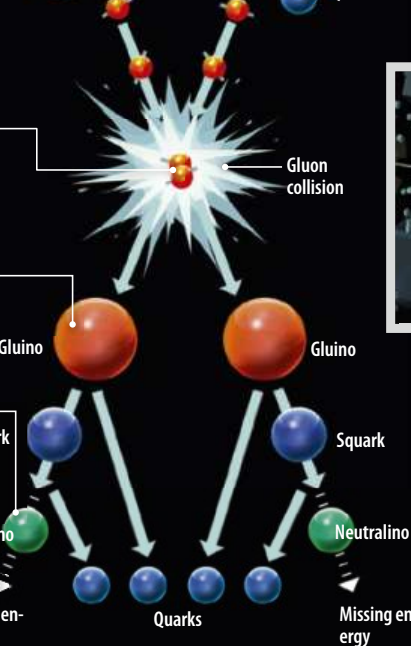
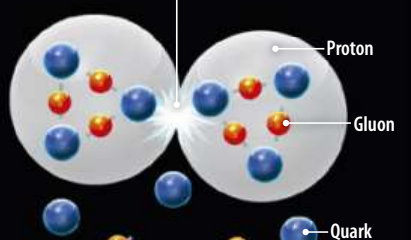
1 If two gluons collide, they can be converted into a pair of gluinos, i.e. the supersymmetric particles of gluons.

2 Each gluino decays into a quark and the twin particle squark. The squark is broken down into a quark and the lightest twin particle, known as a neutralino, which consists of higgsinos, according to theory.

3 Neutralinos are stable, but do not react with ordinary matter, and they escape from the detectors without being directly measurable.

4 Physicists measure the total energy of each collision – in this case four quarks. If energy is missing corresponding to the predicted mass of two neutralinos, they have the proof of twin particles.

A proton consists of three quarks and three gluons. Gluons are the power-transmitting particles that bind the quarks together in the proton. In the collisions, both gluons and quarks are spread.



COPYING THE BIG BANG TO REVEAL EXISTENCE OF TWINS

TWIN PARTICLES DISAPPEARED

Right after the Big Bang, the twin particles disappeared from the visible universe. The epic energy levels at which matter collided after the Big Bang cannot be recreated in modern accelerators, but physicists hope that twins may appear at lower levels.

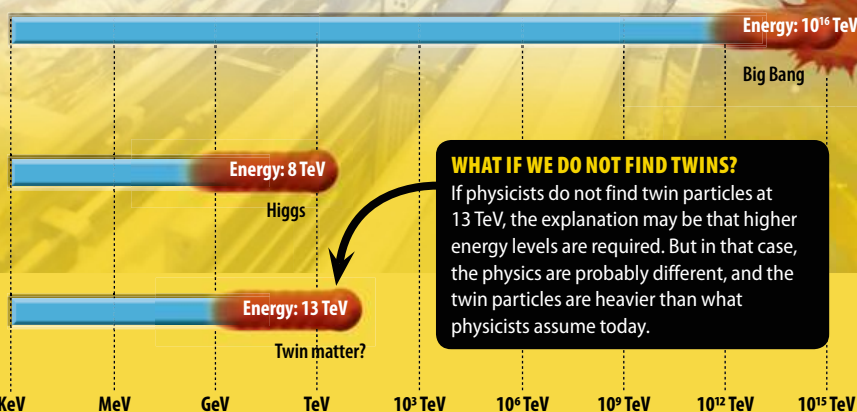
LHC 2012: HIGGS PRODUCED

In 2009–2013, the LHC supplied 8 TeV – enough to produce the Higgs boson, that provides other particles with mass.

LHC 2015: SUPERSYMMETRY SEARCH

After the upgrade, the LHC boasts 13 TeV – probably enough to produce twin particles.

Immediately after the Big Bang, the twin particles were probably visible, but as the universe started to expand, they became invisible. Now, physicists are trying to recreate the twins via huge collision energy levels.



"Go home and cry?" I say.

"Haha," he laughs, "I never heard that one before. Others say that they will party or spend all of their money. Personally, I would get a second opinion."

Of course. Mendes is referring to the double experiments that physicists always carry out in the ATLAS and CMS detectors. The detectors both measure the decay of the collisions, but in very different ways. ATLAS measures the decay fragments in several different ways at the same time, whereas the CMS only measures in one way. So, the CMS focuses less on the accurate angles of the fragments, but it provides a better impression of the particles' mass. With the two detectors, scientists can carry out –

almost – identical experiments in two different ways. If one detector spots an interesting collision pattern – such as when the pattern of Higgs was first observed – the other one must see the same thing for the result to be valid. The very double results meant that Mendes dared believe that they had observed a decay pattern from Higgs back in 2012.

"First, I was extremely sceptical, as I was afraid that we were imagining things. But when I saw the ATLAS results, I was sure that the calculation was correct."

HIGGS IS THE KEY

Higgs is "old news" in a world in which everyone is searching for twin particles. But neither Mendes nor his colleague, theorist Matthew McCullough, are finished with Higgs.

"Many standard model particles are similar, but Higgs is one of a kind and may very well be the link between the matter that we know and the matter that we cannot feel," McCullough says.

As the twin particles must have mass, they probably bind to Higgs, which can consequently give away the twin matter. "We expect Higgs to have an entire family of



The ATLAS detector finds which particles are produced when protons collide at close to the speed of light.



The epic incomprehensibility of the LHC. Amazingly, there are humans who understand this thing!

twin particles, which we hope to unveil," Mendes says.

Although the LHC does not discover twin particles at 13 TeV, they may still exist – it only requires that they are much bigger than predicted by theories. Does Mendes think that the LHC will find twin particles:

"It is not my job to think. It is my job to analyse data to discover how things work."

Whether the twins exist, we will hopefully find out before the summer of 2018, when the LHC will be shut down again, according to plan. **SCI**

THE WHEEL: *REINVENTED*

Since John Boyd Dunlop developed the rubber pneumatic wheel, all car wheels have looked more or less the same. In the future, wheels could be airless, change shape when needed, and generate power, though they will still be circular like the tyres and rims we know today.

By Jens Trabolt

FLOATING TYRES



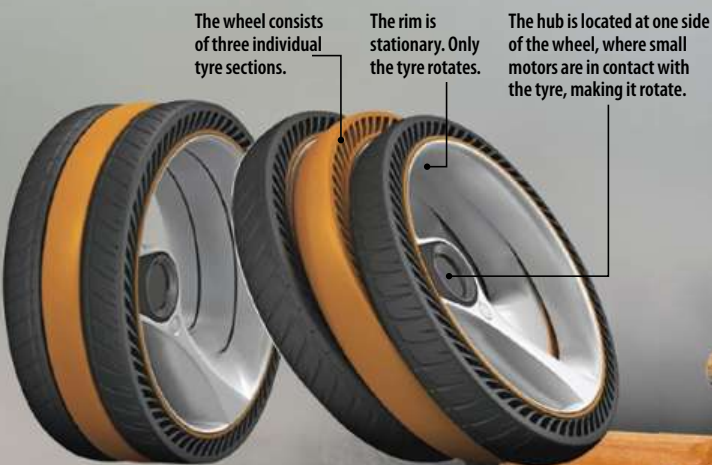
Magnets replace traditional wheel spokes in the Mag-Trac concept wheel. Identical poles in tyres and hub keep the car in the air, while electromagnets with opposite poles, which are turned on and off, provide acceleration.

The car's suspension is automatically adjusted by a computer, which is connected to the powerful electromagnets of the hub. The system provides the car with optimal suspension, no matter the surface.

The wheel makes heavy, space-consuming, and costly parts such as springs and shock absorbers obsolete. So, the car becomes lighter, less energy-consuming, and more spacious. Moreover, Mag-Trac allows you to control the vertical wheel angle during driving, improving directional stability, road grip, and handling.

The electromagnets only work when powered, so when parked, the car will "sink", the hubs resting on the tyres.

WILD VISION



ALLAN HØJEN, HANKOOK

TILTING WHEELS

Two-wheeled vehicles lean inwards in curves in order not to roll over – and so will cars.

Centrifugal force is the enemy of cars that move into curves at a high speed. The car's centre of gravity shifts, very much reducing the road grip of the innermost wheels in the curve. At worst, the tyres will completely lose traction with the road, making the car skid.

The Tiltread concept wheel insures that fast cars get a better grip in curves. The wheel, which is primarily aimed at racing cars, has three parts, and in curves, the individual parts shift, ensuring tyres keep contact with as much road as possible.

The rim of the wheel is fixed and will not rotate. Only the tyre itself rotates during driving. Three small motors – one in each tyre section – are placed in the hub. They transfer the driving torque to the tyres, which are otherwise only in contact with the rims via a number of flexible bearings.

WILD VISION



TYRES CHARGE BATTERY

Goodyear's BH03 concept tyre was designed for electric cars, taking advantage of the heat produced by the wheel in its friction with the surface to generate electricity. The heat from the tyre is directed to a thermoelectric material in the wheel hub that converts the heat into electricity. This electricity flows into the car battery and engine.

The wheel doesn't just generate power when the car is moving. The tyre is made of ultrablack rubber, which absorbs heat from the surface and sunlight, when the car is parked.

Also, the contact patches include piezoelectric elements: crystals that generate electricity when subjected to motion and pressure.

Special rubber collects heat from light and surface.

Piezoelectric elements convert pressure and motion into power.

The heat is converted into power by a thermoelectric material.

COMING UP

A cooling system makes sure that the tyre does not overheat.



THE SPOKES ARE SPRINGS

READY TO ROLL

The hub can move 4.5 cm up and down to absorb shocks.



Loopwheel is a new type of wheel for bikes and wheel-chairs, in which the spokes act as springs. In case of a jolt, the hub shifts in relation to the wheel.

The rim is made of hard aluminium, whereas the three springs are made of flexible

carbon fibre, which keeps them very light. The added weight as compared to traditional wheels is only 300 g per wheel – much less than a sprung front fork.

The Loopwheel also allows for the use of airless tyres without much loss of comfort.

PATCHES ENSURE GRIP

Steep slopes, heavy, deep mud, and stony, bumpy soil – car tyres are pushed to the limit in such terrain.

The Motiv offroad concept wheel is designed for such harsh conditions. The wheel is divided in two lengthwise, and the sides can shift in relation to one another if the car hits large stones, etc. Each side is equipped with 22 tread contact patches that move independently of each other during driving. The wheel can actively adjust each individual part of the tread pattern, moving it back or forth several times during each rotation.

As a result, the car has extreme road grip, tough offroad suspension, and minimum road friction.

WILD VISION



Tread contact patch

SPOKES MAKE WHEEL LIGHT

In this concept, heavy metal spokes are replaced by a flexible artificial material, and the tyre is puncture-proof.

For more than 10 years, engineers from the Michelin tyre manufacturer have been developing an ultralight wheel with prime driving qualities and a stable road grip. The result of their efforts is Tweel.

The invention fits wheel and tyre into the same structure. No more inflexible metal spokes and an air-filled tyre. The contact

patch consists of massive rubber, improving safety: The risk of dangerous and sudden punctures is nonexistent, and the tyre pressure needs no longer be tested.

Flexible spokes made of synthetic material replace metal spokes. In case of a rugged road surface, they will adjust, ensuring the same comfort as air-filled tyres.

**WATCH VIDEO
OF THE TWEEL
IN ACTION**
Yes it looks plenty weird,
but it could save you a lot
of money in tyre wear.
[youtu.be/
13nZKynpeGo](https://youtu.be/13nZKynpeGo)



Tweel has already been tested and is used for cars and excavators.



Steel and synthetics make wheel stable

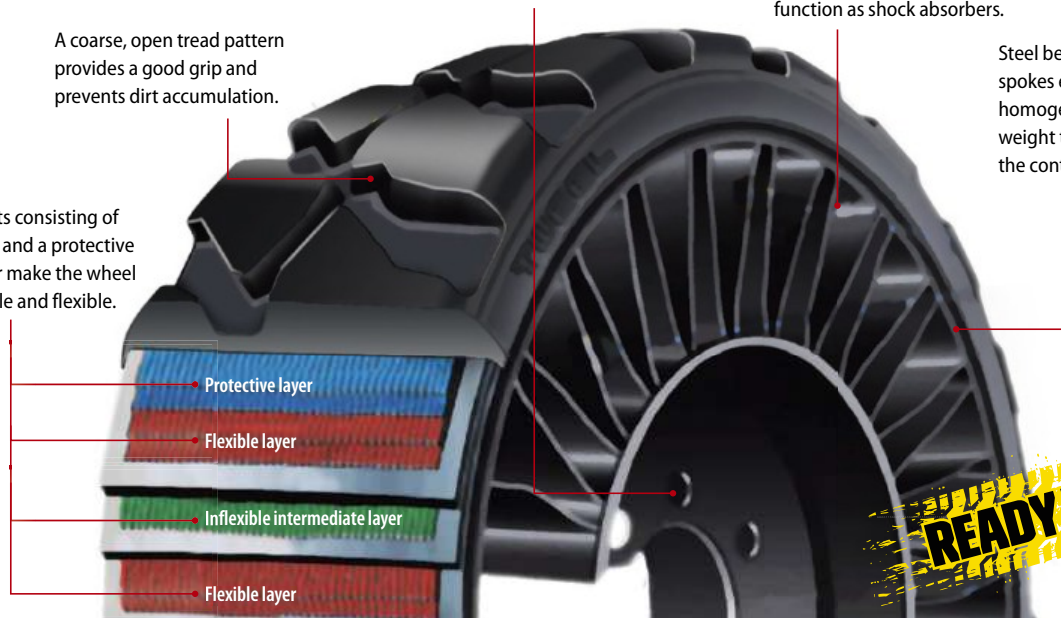
The hub is made of hard steel and replaceable to fit all types of cars and earth-moving equipment.

Spokes made of polyurethane provide the wheel with transverse strength and function as shock absorbers.

A coarse, open tread pattern provides a good grip and prevents dirt accumulation.

Three belts consisting of steel wire and a protective steel layer make the wheel both stable and flexible.

Steel belts and spokes ensure homogenous weight transfer to the contact patch.



READY TO ROLL

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MA/39

SCIENTISTS CONQUER OUR DREAMS



SHUTTERSTOCK

For millennia, dream interpreters have been looking for hidden symbols in dreams. Now, scientists have conquered the world of dreams with brain scans and physical tests, producing a new type of dream interpretation, which claims that you are a good trouble shooter, if you can control your dreams.

By Gorm Palmgren

After having struggled to climb the steep slopes, you have finally reached the mountain peak, looking at the dizzying abyss of the valley in a state of total exhaustion. But a sudden gust of wind makes you stagger, falling from the mountain with your arms and legs desperately thrashing and kicking in the air. As you quickly fall towards the ground, you feel the wind against your body – until the air feels like a protective cushion keeping you up. Instead of falling, you are flying through the air like a bird.

Of course you are not really flying. You are lying in your bed, dreaming. But when do you realise this? Most people do not know that they were dreaming until they wake up again, but others may already realise it in their sleep and take control. Instead of falling into the abyss, they are flying above a lush rain forest or visiting a land of make believe.

This type of dream is known as lucid, and if you have such dreams often, you are a little smarter than most other people. That is the conclusion of one of a series of new scientific studies that all have to do with what our dreams mean to us. With the studies, scientists have made their entry into

our dreams, including a brand new interpretation to replace the symbols of classic dream interpretation.

LUCID DREAMS, LOGICAL THINKING

One of the dream interpreters is Patrick Bourke from the University of Lincoln. According to him, when people with lucid dreams are able to see through the façade of a dream, it is an indication that they are better at seeing through reality, and they should also be able to use this ability when they are awake to solve problems which require logical thinking.

To test his hypothesis, he selected 68 university student test subjects, dividing them into groups according to how often they had lucid dreams. Bourke carried out a series of logic tests such as one, in which he introduced the students to three words that seemed not to be connected, for instance “sand”, “mile”, and “age”. The students were to come up with a fourth word that could be placed in front of or behind them all – in this case the word “stone”. The experiment showed that students who had a lucid dream at least once a month solved 29 ►

5 CLAIMS ABOUT DREAMS

TRUE OR FALSE

1

EVERYBODY DREAMS

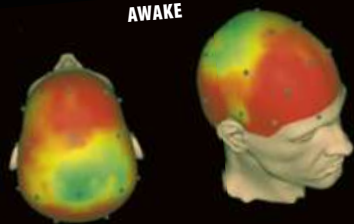
Almost 33 % of the participants of an Austrian study say that they never or very rarely have dreams. But that may just be due to the fact that they cannot remember their dreams. When we are dreaming, we are in the sleep phase known as REM, which is characterised by Rapid Eye Movement. So far, scientists have not come across people who never go through the REM phase, but we do not know for sure if everybody has dreams during the phase.

In rare cases, brain damage has the effect that people become unable to dream. Charcot-Wilbrand syndrome (involving dream loss) can be caused by cerebral haemorrhage, a cerebral blood clot, or even Alzheimer's disease.

FALSE

Activity level in the brain
LOW HIGH

AWAKE



LUCID DREAM



REM SLEEP



Scientists' measurements of brain activity reveals that lucid dreams occur as a "crossbreed" between being awake and REM sleep.

HOW TO CONTROL YOUR DREAMS

The key to controlling your dreams is knowing that you are dreaming.



Remembers as many details of your dreams as possible by writing them down. That will help you identify elements that are repeated. If you recognise them, they may reveal that you are dreaming.

► % more problems than the ones who were always passive onlookers in their dreams. And the difference became even bigger, when the problems were really difficult. In those cases, the lucid dreamers came up with 79 % more correct answers than the students who did not have lucid dreams.

Elisa Filevich from the Max Planck Institute for Human Development in Berlin has found indications that lucid dreamers are more analytical. Scanning the brains of lucid dreamers and people who only had ordinary dreams, she found that two areas at the front of the frontal lobes are bigger in lucid dreamers. According to scientists, those areas hold the capacity of reflection and analysis.

ELECTRIC CURRENT MAKES LUCID DREAMS

Many people cannot control their dreams. According to studies, 19-37% of the population have lucid dreams at least once a

month. But Ursula Voss from the Goethe University in Frankfurt, Germany, has developed a method for taking control in a dream. By applying a weak current of 25 or 40 Hz to the brains of test subjects as they go through REM sleep, she was able to produce the type of activity in the brain which is typical in connection with lucid dreams. Test subjects all subsequently explained that they knew that they were dreaming and could control the dream.

But although you are one of those who cannot take control of your dreams without "help", the dreams are still important to you. They make it easier for you to learn by improving the procedural memory that remembers processes – such as how to ride a bike, button your shirt, or play the piano. Tore Nielsen of the University of Montreal, Canada, demonstrated this, when he made 22 test subjects play the game "Corsi block-tapping", which is about observing another person randomly tap a number of blocks, and then

2

FALSE

EVERYONE CAN REMEMBER DREAMS

You wake up suddenly from a dream and try to remember what it was about – but it slips away like sand between your fingers. Some people can almost never remember their dreams, whereas others can remember many, and scientists now know why. Brain scans of people who tend to remember or forget their dreams show that those who remember are generally characterised by much more activity in the part of the brain that directs attention to impressions from their surroundings when they are awake. In other words, attentive people are better at remembering, asleep (dreaming) or awake.



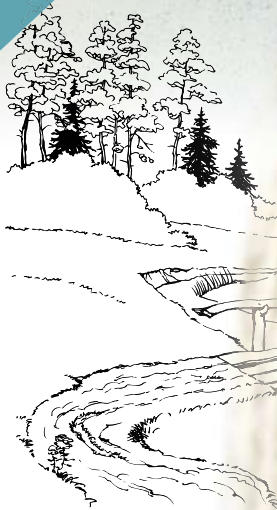
When you are dreaming, and when you are awake, the same part of the brain is active. Its degree of activity determines whether you can remember your dreams.

When you go to sleep, you must think that you want to focus on finding indications that you are dreaming – such as things that could not happen in the real world. Flying is one example.



repeating the sequence. The experiment showed that the longer the test subjects spent in REM sleep, the faster they learned to remember the right sequence.

Dreams are also important when it comes to handling real life emotions and developing better social skills. Matthew P. Walker from the University of California, Berkeley, discovered this by introducing test subjects to photos of a man who looked scared, angry, or happy. The test subjects were to guess the man's mood and were subsequently divided into three groups: one whose members slept, but did not dream, one whose members slept and dreamt, and one whose members did not sleep. Subsequently, the test subjects were ►



Blind people can draw the things they experience in their dreams.

3

SOME BLIND PEOPLE CAN SEE IN THEIR DREAMS

TRUE

Even people who were born blind and have consequently never seen anything may “see” things in their dreams. Danish scientists have discovered this by studying the dreams of a group of people with normal vision and a group who were born blind. The first group always see scenarios in their dreams, but surprisingly, **21 % of the blind people's dreams are also scenarios/images** and usually even in colour. However, the images are rather blurred, and they are five times shorter than those experienced by people with normal vision.

This is so, because congenital blindness does not necessarily mean that the visual centre of the brain does not work. Previous

experiments have shown that blind people who never saw anything in their entire lives are still able to produce images in their brains. Scientists have learned this based on measurements of brain waves in the visual centre which show evidence of activity. The explanation may be that the visual centre is stimulated by nerve impulses from other senses such as hearing and the sense of touch, which produce the images in the brain instead. In other experiments, the blind people were also able to **draw sketches of their dreams, when they woke up the next morning, including people, landscapes, and different objects** that they saw in their dreams – in blurry, but recognisable line drawings.

SHUTTERSTOCK



Before you fall asleep, tell yourself that in your next dream, you will discover that you are dreaming – that will help you remember it.

4

PATIENTS DREAM DURING SURGERY

TRUE

Pleasant dreams without scalpels and blood. That is what around 25 % of patients experience, as they are lying on the operating table under a general anaesthetic, according to an Australian study. The dreams that we have during surgery are typically about holidays and family, they are not related to the surgery.

In the vast majority of cases, the anaesthetic is able to suppress the mind, so the patient remains in his dreams, feeling nothing. But the situation may develop into a nightmare for about 2 in 1,000 patients, whose senses "defeat" the anaesthetic, so they witness

their own surgery. They are aware of what the surgeons are doing to them and are subsequently able to explain it in detail. In the worst cases, the patients can also feel intense pain, but are paralysed and unable to alert the surgeons. The phenomenon may be due to patients being under too little anaesthetic, or perhaps they are immune to its effect.





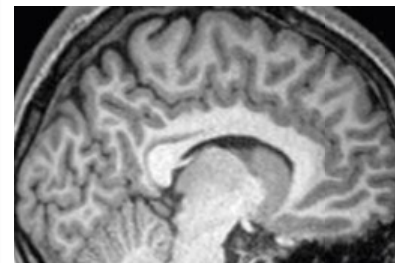
Set your alarm clock for an early hour and stay awake for a while, before you go back to sleep. Interrupted sleep blurs the boundary between being awake or asleep, making you more aware in your sleep.

5

TRUE



Brain fold



People who have difficulties distinguishing between imagination and reality are missing a tiny fold in their brain.

PEOPLE CAN CONFUSE DREAMS AND REALITY

The ability to distinguish between dreams/imagination and real events may fail even in healthy people. According to studies, 50-73% of all people have recollections about experiences that they are unable to link with a certain event and so, they really do not know if they experienced it or if it was just a dream.

The boundary between imagination and reality is even more blurred in people who lack a certain fold deep inside the brain. Known as a PCS, the fold is formed at a late point in foetal development, and it guarantees that we do not mix up imagination and the real world. But 27% of all embryos do not develop the fold, and those people hear and see things that do not happen in reality.

The phenomenon was demonstrated by a British scientist, Jon S. Simons, from the University of Cambridge. He introduced test subjects to cards with texts such as "Laurel and ...". When the test subjects were subsequently asked to repeat what the card said, people without the PCS fold more often replied "Laurel and Hardy", though Hardy had been left out.

Perhaps understandably, people who do not have the PCS fold are somewhat more likely to develop schizophrenia.

asked about the man's mood again. The results showed that dreams were very important when it came to processing the first hand impression of the man. The test subjects who had not slept intensified the negative emotions, so the scared and angry man became even more scared or angry. But the test subjects who had experienced dreams in their sleep did the opposite. In their opinion, the scared man had become less scared, whereas the happy man was even happier. The test subjects who had slept, but without dreaming, did not change their minds about the man. This made Matthew P. Walker conclude that dreams perform the important task of processing negative emotions so they do not take hold in the shape of anxiety or fear in real life.

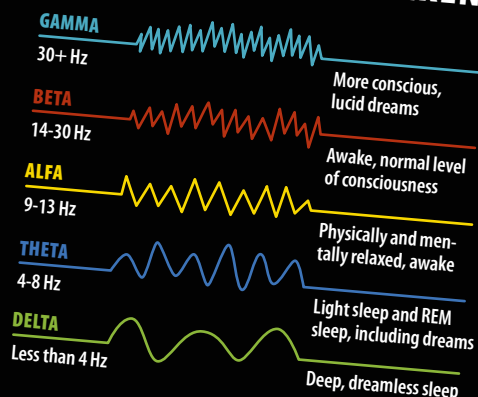
NIGHTMARES REPLACED BY DREAMS

However, dreaming can also be harmful. Some 80% of all PTSD (Post-traumatic Stress Disorder) patients have nightmares several times a week. In their dreams, they relive their traumatic experiences, so their anxiety is constantly fuelled.

But according to several psychiatrists, the dreams may also hold the solution to the problem. If the patients can learn to have lucid dreams, they can discover that their nightmares are not real and that there is no danger. Perhaps they can even choose to wake up instead of undergoing the nightmares or to take control of the dream and make it less scary.

Even when you do not suffer from PTSD or nightmares, lucid dreams could still be beneficial. In those, you can escape your everyday life and be the director of your own dreams, staging relaxing flights above exotic rain forests or visiting idyllic lands of make believe. **sci**

BRAINWAVES ARE DIFFERENT



Your brain activity varies according to what you are doing – from near-unconsciousness to hyperactivity.

A CURE FOR OBESITY?

By Rasmus Kragh Jakobsen

New pills, syringes, and devices "delete" extremely overweight people's craving for food. According to new research, the struggle against obesity cannot be won via healthy food and exercise alone. The battle must be fought in the brain - and in the gut.

A new device **shocks nerve paths**, "deleting" the feeling of hunger.



A new pill **activates cerebral pleasure centres**, making the patient feel full.

A new syringe with **hormone fools the brain and the organs**, so the patient loses weight.

He was unable to walk and had not left his home for more than 10 years. His breakfast consisted of six fried eggs followed by pizza, kebab, Chinese takeaway, and finally a bunch of Big Macs for dinner – plus two litres of coke to go with everything. The man, who ate all this food, was Keith Martin of the UK.

He knew that he was killing himself with his huge food intake, including 83,000+ kilojoules a day – about 10 times as much as the recommended daily intake. When Keith Martin weighed 450 kg, his gloomy prediction came true: In December 2014, his body quit. He died at the age of 44 – of pneumonia caused by obesity.

Annually, almost three million people die as a result of extreme obesity. Often, their death is caused by illness such as cardiovascular disease, diabetes, and obesity-related cancer. On a global scale, 2.1 billion people are overweight, and extreme obesity is just as costly to the world community as smoking or the struggle against armed violence, war, and terrorism.

But now, researchers have discovered new drugs that may be able to oppose the growing obesity problem.

EFFICIENT NEW DRUG

One of the new, promising weight loss drugs is Saxenda, which was developed by Danish pharmaceutical Novo Nordisk. Saxenda features a hormone-like ingredient, which has just been approved by American and European health authorities. The ingredient has been approved for the treatment of severely obese people with a body mass index of 30+.

BMI, which is the most widely used definition of obesity, is a measure of weight as compared to height. BMI is found by dividing the body weight (m) with height (h) multiplied by height (h): $(\text{BMI} = m/h^2)$. ►

WEIGHT LOSS:

8.5%

According to tests, the device helps obese people lose at least 8.5 % of their body weight.

50 % lost at least 20% of their body weight.

Electricity shocks nerves

A pacemaker-like device blocks nerve paths which are responsible for the feeling of fullness and hunger.

The vBloc device functions like a rechargeable pacemaker. The small electronic weight loss device emits electric impulses that block nerve signals concerning hunger going towards and away from the brain. The lacking nerve signals mean that the patient does not feel hungry. The device is implanted into the body via a procedure, which is much more

gentle than traditional obesity surgery, in which the stomach is constricted. Electrodes are inserted around the vagus nerve, and the device subsequently emits impulses regularly during the patient's waking hours. The nervous system will not become immune to the treatment, and so, it can continue for years without the patient feeling hungry.

3 The electric signals block out nerve impulses from the stomach to the brain and vice versa. Without the nerve impulses, the person does not feel hungry.

2 vBloc electrodes are placed on the vagus nerve, which links the brain with the stomach and organs such as the pancreas.

1 The vBloc device is placed under the skin of the stomach in a suitable place and is electromagnetically recharged daily from the outside like an electric toothbrush.

► People with a BMI of 25+ are overweight, 30-40 means severely obese, and if you have a BMI of 40+, you are morbidly obese, and you risk suffering blood clots, brain haemorrhage, or diabetes due to the huge burden on your body.

DRUG DISCOVERED BY ACCIDENT

Novo Nordisk is famous for its diabetes drugs, and the new weight loss drug was discovered by accident in experiments with diabetes patients. Much to their surprise, scientists observed that some of the patients lost weight when taking the diabetes drug Victoza, which controls the blood sugar level by making the pancreas produce insulin after a meal.

The active ingredient of Victoza is the same as in Saxenda, only a lower dose. Saxenda studies carried out at hospitals throughout the world have demonstrated that the drug produces an average weight loss of 8 %, and unlike many other weight loss drugs, it involves few side effects.

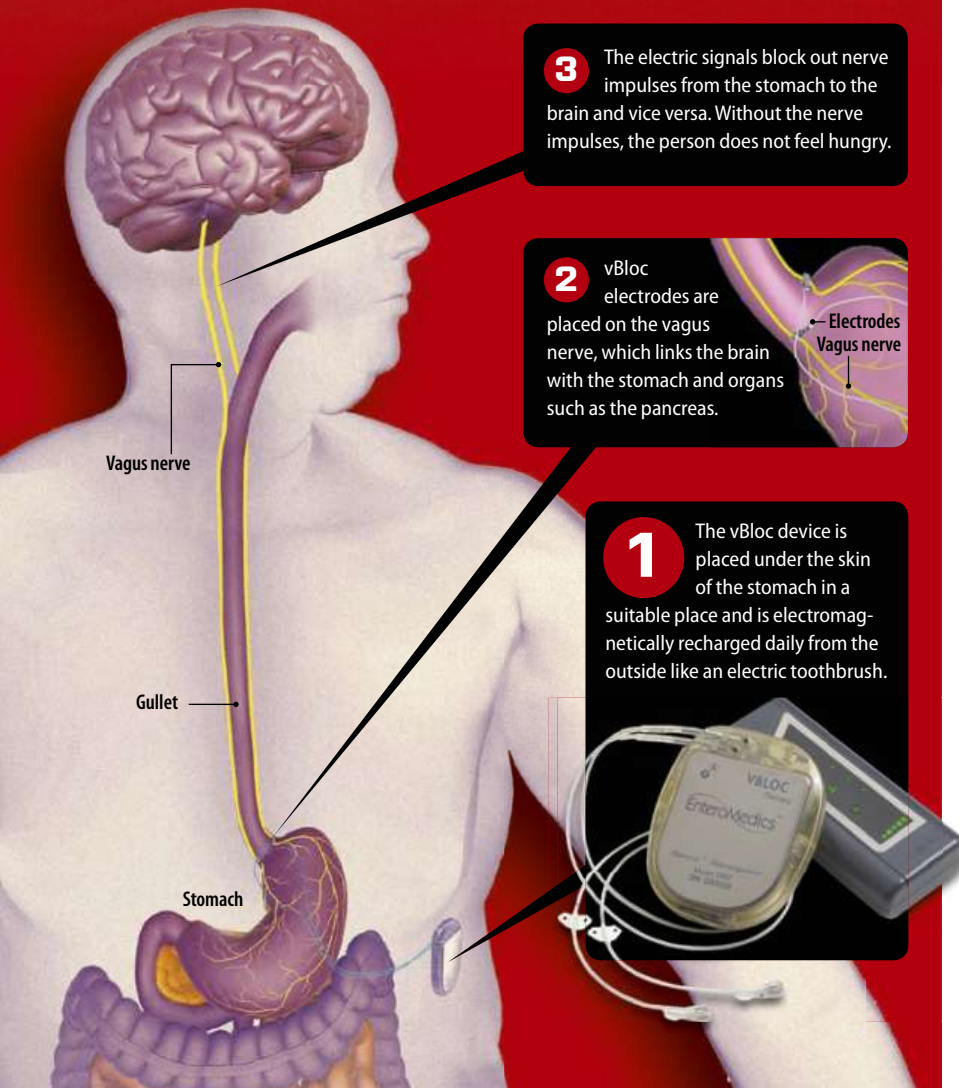
Until a few years ago, most scientists thought that obesity is only about calory intake. But new scientific research shows that the problem is much more complex. Recent studies indicate that the answers to why we become obese are to be found in our genetic material, in our faeces, and in industrially produced food.

STONE AGE BODY IN NEW ERA

According to scientific research, people do not become equally fat from consuming the same amount of food. It turns out that obesity develops gradually without scientists being able to measure it.

When scientists calculate a person's energy intake, they often observe that the daily excess calory intake is not necessarily any more than 5 g of chocolate. That is so little that scientists cannot predict who will become overweight and who will remain slim after consuming the few extra calories. The paradox can probably be explained by a combination of genetics and metabolism.

In terms of evolution, the people who easily become obese are the winners, as obese people have "obesity genes", which have historically enabled them to survive in times of famine, as they could "store" more food in their bodies in the shape of fat for hard times. Today, many of us are the descendants of these survival experts, and consequently, we are experts on taking





450 kg

– that is how much Keith Martin of the UK weighed, when he reached his maximum weight.

CHANNEL FIVE/FERRARI PRESS/ALL OVER

advantage of the energy of the food. Nowadays, people in the western world always have access to calories and so, the ability to store fat becomes a problem instead of an advantage. The average modern person has such extensive energy stores that he can easily survive for a month without food by just burning his fat.

OBESITY IS A MYSTERY

Biologically speaking, obesity is a natural condition for the human body, and consequently, it was previously a mystery, why the fat makes us sick. Many animals such as migratory birds and bears can store large amounts of fat without suffering any harm. Moreover, women have about twice as much fat in their bodies as men without suffering any harm. Some peoples even tolerate obesity better than others. Asians cannot become as fat as Europeans without developing diabetes and other diseases resulting from obesity. So, diabetes is very common among Asians, though they are averagely not as obese as Europeans.

Recent scientific research has shown that the diseases develop, as the cells and tissue of the body can no longer handle the large amounts of fat properly. Fat is stored in fat cells as tiny oil droplets that consist of fatty acids.

But at some point in time, the cells are unable to store any more fat, and suddenly, free fatty acids start to move beyond the fatty tissue. The free fatty acids cause cell damage and chronic inflammation of the

tissue. The metabolism suffers damage, and the person develops diabetes.

GENES REVEAL LOCATION OF FAT

Part of the explanation of obesity is to be found in the genes. Two extensive studies conducted by scientists from the University of North Carolina and the University of Michigan in the US focus on the complex relation between genes and obesity. Scientists studied genetic data from more than 500,000 people, comparing genes to BMI and waist and hip measurements. The scientists spotted 146 areas of our genetic material that play a role in the development

of obesity in two different ways. In some 33 % of the areas, there are genes which determine our metabolism and how fat is stored by the body. This knowledge is interesting in connection with obesity-related diseases. People who measure more around their waists than around their hips more often develop obesity-related diseases than people whose fat is primarily stored in other places but the stomach area. Fat between the internal organs is much more hazardous than fat located right beneath the skin on hips and thighs. The genetic regulation of the fat deposits also varies between the sexes, and this may explain why men get sick faster due to fat around ▶

Weight loss drugs with side effects

In spite of a quick weight loss, drugs often involve unpleasant side effects such as oily faeces and addiction.



■ **Orlistat** prevents the guts from absorbing some 30 % of the fat in food. The side effects are **incontinence and oily faeces**. The patient typically loses 2-4 kg, when the drug is combined with exercise and a change of diet.

■ **Phentermin** has the same effect as the illegal amphetamine drug, also known as speed. Phentermin stimulates the adrenal glands to release noradrenaline – a stress hormone, which speeds metabolism and reduces appetite. The drug is only approved for obese people who are fatally overweight, and it may cause **addiction, elevated blood pressure, and heart trouble**.

■ **Phentermin-topiramate** combines the amphetamine-like drug phentermin with topiramate, which relieves heart trouble. The drug has been approved for long-term use, but may cause **high cardiac rhythm, tickling hands and feet, constipation, and suicidal thoughts**. The patient typically loses 5-10 % of his body weight.



WEIGHT LOSS:
5% According to tests, the drug helps 25% of patients lose at least 5% of their body weight. Some 14% of the patients lose 10% of their body weight.

Pill activates pleasure centres

The drug lorcaserin produces weight loss. The exact mechanism is not known, but scientists do know that the drug binds to serotonin 2C receptors on neurons in several places of the brain. In a particular part of the brain known as the hypothalamus, the drug causes increased production of the POMC neurotransmitter, which makes people feel full. In the hypothalamus, lorcaserin makes the receptors constantly active, so the patient does not feel hungry. The drug also causes increased production of serotonin, which is central to mood and sex drive. Serotonin receptors are already targeted by several anti-depressants. Lorcaserin only activates the serotonin receptors that control the feeling of fullness.

The lorcaserin weight loss drug is also known as Belviq. It was approved in 2012.



► their waists than women. The other two thirds of the areas contained genes that control our sensitivity to food. People with low sensitivity will more often keep on eating, although the body does not need any more energy. Based on our genes, scientists can tell our biological ability to store fat and our inclination to eat. Nevertheless, scientists estimate that genes only account for some 20 % of the BMI differences. 80 % have to do with nurture, life style – and perhaps even our faeces.

THIN WOMAN WAS GIVEN “FAT FAECES”

In our intestines, there are ecosystems of microbes that benefit from the heat inside our bodies and the moist environment with a constant supply of nourishment. The bacteria help us digest and absorb food and exercise the immune system.

The bacteria are vital to our health. In 2014, a woman had a faeces transplant. She suffered from a potentially lethal type of diarrhoea, and as no other treatment worked, doctors decided to give her a new intestinal flora. The woman's daughter, who was severely obese, donated the faeces, from which doctors took bacteria and transferred them to the woman. The diarrhoea stopped, but in addition, something strange happened. She gained weight, and she kept on doing so. After 36 months, she weighed 85 kg and had a BMI of 34.5 – just like her daughter. Experiments also show that obese people can slim down, if they get a new intestinal flora from thin people. In other words, it pays off to protect your intestinal flora, so it will work to keep you slim and healthy.

CHEMICAL SOAP IS BAD FOR GUTS

A group of chemicals called of emulsifiers probably also play a central role in the development of obesity. Chemically speaking, emulsifiers are a type of soap that can hold liquids together which normally do not combine, such as oil and water. Products like salad dressing and ice cream typically contain emulsifiers. Just like the obesity epidemic, the use of emulsifiers has grown to extreme levels since World War II, and now, a

66

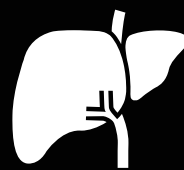
Genes only account for 20% of BMI differences. 80% comes from upbringing, life-style, even our poop

study by the US Georgia State University shows that two of the most common, CMC and P80, dissolve an important mucous layer on the inside of our guts. In mouse

experiments, the animals' intestinal walls became porous, when they were fed the emulsifiers. The intestinal bacteria penetrated the wall, challenging the immune system. The mice developed a light inflammation of the intestines, just like people with obesity-related diseases. Moreover, the numbers of intestinal bacteria changed. The harmful types of bacteria gained ground, and the mice became obese and ill. This worries scientists, who will now look into whether emulsifiers have the same effect on humans. If so, we should avoid emulsifiers to stop the breakdown of our intestinal walls.

In the meantime, people of the western world are growing heavier, but an ancient Chinese herb promises extensive weight loss. Known as *T. wilfordii*, the herb made mice lose up to 45 % of their body weight. The active ingredient reduces a certain type of stress in the cells, so the body responds better to the leptin hormone. Scientists used to consider leptin the key to extensive weight loss, but patients who only took leptin did not lose much. Combined with the herb, results were fantastic, so the next step will be developing a drug based on the herb. [SCI](#)

4 The hormone prevents the liver from releasing too much sugar to the blood at a time.



5 The hormone makes the beta cells of the pancreas produce insulin, when the blood sugar level is high after a meal. Insulin opens up the cells, so the blood sugar can enter. Many obese diabetes patients need insulin to get the sugar out of their blood.



Drug curbs hunger signals

A new drug by the name of Saxenda copies one of the body's own digestive hormones. The artificial hormone reduces the feeling of hunger.

The artificial liraglutide hormone copies the body's own GLP-1 hormone. During meals, the hormone is released by the small intestine, reducing the feeling of hunger. The hormone is produced naturally, when the brain registers that the stomach expands, and when the stomach starts to produce more digestive enzymes

to break down food. Unlike GLP-1, liraglutide is designed not to be broken down fast in the body. So, the blood stream level is stable, and the feeling of fullness lasts longer.

In the brain, liraglutide intensifies fullness signals from a type of nervous cells, curbing hunger signals from another group of nervous cells.

WEIGHT LOSS:

5%

The drug makes 60 % of patients lose at least 5 % of their body weight. Approximately 30 % of patients lose 10 % of their body weight.

3

The hormone makes the stomach slow down digestion, so the blood sugar becomes more stable, as the digestion lasts longer.



1

A hormone is injected under the stomach skin or into the upper arm.



2

The drug finds its way to the hypothalamus. There, it curbs signals from "hunger neurons" and intensifies signals from "fullness neurons".



1 October
1908

Ford introduced its Model T, which was such a success thanks in part to the assembly line.



CORBIS/ALL OVER

➤ **Past and...**

How Henry Ford got the world its first set of wheels

Ford's Model T may be the most important car in history. It was so cheap that automobiles were no longer only for the wealthy. Ford's use of the assembly line was a technological leap that came to define manufacturing in the 20th century... and beyond.

By Ebbe Rasch

When Henry Ford introduced his Model T on 1 October 1908, competitors shook their heads. Back then, automobiles were luxury items reserved for the elite of society. But the Model T had neither the comfortable plush seats of a limo nor the powerful engine of a racing car. The project was doomed to failure.

But Henry Ford's target group was very different. Model T was a simple design made for ordinary people. Ford did not intend to sell a few costly cars to rich customers, he wanted to sell tens of thousands of cheap, ordinary cars, putting the whole of America on wheels. In most people's opinion, that was completely unrealistic. But Ford proved them wrong.

EVERY SECOND CAR WAS A FORD

At its launch, the Model T only cost \$850 (about \$20,000 today), making it affordable for skilled workers. So the car became an instant success.

At the Ford factory in Detroit, some 2,000 employees worked hard to assemble the cars according to the same principles as all other car manufacturers at the time: The car was built from scratch, and when a worker needed to mount a shaft, a

radiator, or front lights, he went to the spare parts stock room to get what he needed, returning to the workshop to mount it. In spite of the old-fashioned methods, Ford manufactured 10,000+ Ford Ts in 1908. Not many in comparison to modern standards, but Ford still managed to double the number of cars in America.



GETTY IMAGES

Henry Ford earned a fortune by selling the cheap Model T, which ordinary workers could afford.

Twenty
Passenger
\$850



GETTY IMAGES

At a price of \$850, Ford's model T was much cheaper than other cars in the market.

The manufacture of so many cars meant that workers wasted a huge amount of time getting in each other's way, and it soon became clear that something had to be done to meet the ever growing demand. First, Ford built a bigger factory, but that just made the chaos worse. So, Henry Ford asked his trusted superintendent, Danish immigrant Charles E Sorensen, to find a way to optimise work procedures.

INSPIRED BY SLAUGHTERHOUSE

Sorensen's basic idea was to reduce the time wasted by bringing the work to the worker. Mass production had already been introduced in other industries, and a slaughterhouse became the model for Ford's experiments.

In the huge Union Stock Yards slaughterhouse in Chicago, each worker performed one task, as a conveyor belt moved the meat along, inspiring Sorensen to try something similar.

Automated car production

Ever since Ford introduced assembly line production, the car industry has always been quick to implement new production methods. In 1961, the world's biggest industrial robot was set

to work by Ford's competitor, GM, and today, more than half the world's robots work in car factories. This year, the machines will help weld, assemble, bolt, and paint 70 million cars.

By means of rope, a winch system moved semi-finished cars through the factory past the workers, who each mounted one single part. Sorensen's simple conveyor belt experiment was highly efficient, cutting an incredible 75% off the production time. The method was quickly refined even more, and as Ford introduced real assembly lines in most of the factory, new cars were completed at a still faster

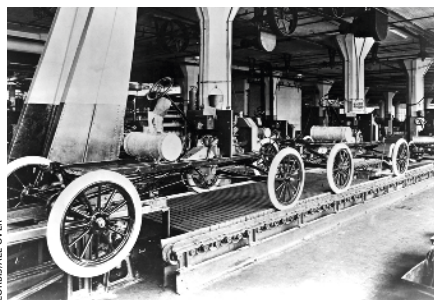
rate. In 1913 – the first year of fully operational assembly lines – Ford built 170,211 Model Ts, and by 1923, the number was a staggering 2,011,125 cars.

When the last of a total of 15 million Ford Ts left the factory in 1927, the model was technically outdated, but had indeed left its mark. Henry Ford earned a fortune, many people owned cars, and almost all industries had assembly lines. SCI



GETTY IMAGES

BEFORE assembly lines, each car was assembled from scratch in a workshop.



CORBIS/ALLOVER

AFTER Ford introduced the assembly line, cars could be built much faster.

Repetitive work = high speed flow

The first work flow to be streamlined by assembly line production was car magneto ignition systems, producing electricity for igniter plugs. During the early years, a worker could assemble a complete ignition system in 15 minutes. But by dividing the procedure into 29 steps and making 29 men carry out one step each along a conveyor belt, 360 systems could be assembled per hour – tripling the efficiency rate.

FOCUS ON

THE DETAIL



CORBIS/ALLOVER

Magneto ignition systems were the first to be assembly line-produced by Ford. Each worker carried out one task – such as fixing bolts.

TOP 10

The Most Powerful Bites

By Bjørn Bojesen

1

SALT WATER CROCODILE

Crocodile drags prey to death

The world's largest reptile, the salt water crocodile, has the most powerful bite of all animals with a force of up to **3,510 kg**. The South-East Asian and North Australian killing machine will sink its 9-cm-long teeth into almost anything venturing into the

waterholes and rivers, which it calls home: fish, turtles, buffaloes, wild boars, birds, and sometimes even humans.

The salt water crocodile pulls terrestrial animals under the water, holding them in an iron grip, until they drown. If the

prey is big, the crocodile uses a dirty trick: Once it has placed its jaws around the prey, taking a firm hold of the animal on the shore, it rotates its own axis, so the prey loses its balance, allowing the crocodile to drag the victim to certain death.

3,510 KG

The salt water crocodile kills its prey by dragging it under the water.

NATURE PL

2

NILE CROCODILE

Nile king is a bone crusher

The African Nile crocodile spends its days sunbathing on the banks of lakes and rivers. At night, it slips into the water, where only its eyes, ears, and nostrils can be seen above the surface. As a zebra, antelope, or

other mammal approaches to drink water, the Nile crocodile rushes onto the shore, bites and grips the animal with a force of **2,268 kg**, and drags it into the water. The croc's bite is so powerful that it will crush anything from bones to turtle shells. On the other hand, the muscles used to open the jaws are so weak that you can keep the animal's mouth shut with a strong rubber band.

A Nile croc places its powerful jaws around a zebra.



3

GREAT WHITE SHARK



The white shark keeps extra rows of new teeth in its jaw, and frequently discards old ones.

Shark rips meat chunks off its prey

In the water, the most dangerous killer of the oceans surprises prey such as fish, seals, and dolphins close to the surface. The shark uses its sophisticated sense of smell and sharp vision to hunt. Its bite of up to **1,857 kg** will instantly kill small

animals. The great white shark kills bigger prey by biting meat chunks off it, until it bleeds to death. For huge prey like whales, the shark uses a unique method, by which it "unbuttons" its upper jaw, opening its mouth wide to catch prey.

These numbers indicate the hardest bites that biologists have measured or calculated for different species. In this article, the forces of all bites are in kilograms. For comparison, the force of a human bite is 77kg.

AGGRESSIVE
HERBIVORE

4 ALLIGATOR



Alligator infects escaped victims

The American alligator bites with a force of **964 kg** and is able to move at a top speed of 40 km/h on dry land. It lives in fresh water regions, consuming a diet of fish, frogs, rodents, deer, wild boars, snakes, and domestic animals. Its mouth is full of bacteria, which severely infect the prey – if it is lucky enough to escape.

5 HIPPO

Hippos can sink riverboats

The hippo is the world's most aggressive herbivore. Most of the time, it only uses its mouth on plants, but when the hippo fights rival males, crocodiles, and humans, it uses the entire force of its bite: **826 kg**.

The bite is particularly powerful, because the hippo can open its mouth at a 150 degree angle. Hippos can sink small boats, and every year, kill people who stray into their territory.



6 HYENA

The hyena has the most powerful jaw relative to body weight.



Hyenas can break a zebra thigh bone

The spotted hyena breaks the bones of the wildebeests, antelopes, and other hoofed animals that it bites. Spotted hyenas hunt in groups during the night. At a speed of up to 55 km/h, they catch up with and isolate the prey, which they bite to death. Hyenas

rarely weigh more than 50 kg, but their bite boasts a force of **561 kg**. Hyena jaws and jaw muscles are among the most powerful in the animal kingdom relative to body weight. When hyenas do not bother to hunt, they feed on carcasses or steal prey from lions.

7 LION

Breaks the prey's neck

Lions hunt in groups, catching up on their prey at speeds of up to 60 km/h. The lion uses the **347 kg** force of its bite to break the necks of small prey such as gazelles, whereas the windpipes of bigger prey such as wildebeests, buffaloes, and zebras are perforated. It is primarily females that hunt.



CLOSE RACE
BETWEEN LIONS
AND TIGERS

8 TIGER



Tears out throats

This striped killer hunts alone, attacking anything from wild boars to bears with a bite force of **307 kg**. Tigers sometimes attack humans. The skull is much like a lion's, and the tiger kills its prey in the same way: Small animals are bitten in the neck, big ones get their throats torn out.

9 POLAR BEAR

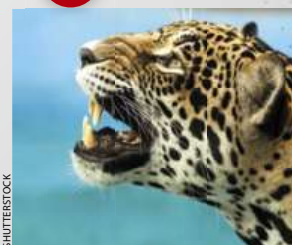
Pulls seals ashore

The polar bear primarily uses its **245 kg** bite to pull seals out of the ocean, killing them on the ice. The bear only feeds on the meat and fat of marine animals. So, it lacks the teeth with

which other bears chew berries.



10 JAGUAR



Bites the prey's brain

In spite of its modest body weight of less than 100 kg, the jaguar has powerful jaws and bites with a force of **241 kg**. This South American feline's hunting method is highly unusual: it bites through the skulls of deer, tapirs, peccaries, etc. in such a way that its teeth sink into the brain of the prey.

TRIVIA

PUT YOUR KNOWLEDGE
TO THE TEST

q. 1



1. What material is often used on the face of a (good quality) watch to protect it from scratching?

2. Which iconic Aussie bird-of-prey is known by the (awesome) scientific name *Aquila Audax*?

3. True or false: if you had a powerful-enough optical telescope, you could see the NASA's landers on the moon from Earth.

4. Also called the "spiny ant-eater", what is the *Echidna*'s preferred food?

5. Where in Australia would you find the volcanic dyke known as The Breadknife?

6. During August/September 2015, an unprecedented how many tropical cyclones began forming at once in the Pacific?

7. What is Elon Musk's Dragon Capsule?

8. What can be up, down, top, bottom, strange or even charmed?

9. On 13 September 2015, what had 37,172,002 pages and 1,343 senior editors?

10. Who has just bought a major stake in National Geographic and plans to turn the 127-year-old non-profit into a money-making business?

ANSWERS ON p82!

q. 4



PERTH 200

q. 5



NATIONAL PARKS NSW

Trivia Countdown (use fewer clues, get a higher score!)

	5 POINTS	4 POINTS	3 POINTS	2 POINTS	1 POINT
1. BIOLOGY Name this insect	The name of the insect is a combination of the Ancient Greek words for prophet and shape.	Some subspecies have wings and can fly. But the insect is primarily known as a brutal, wingless killer.	The insect has 6 legs, but only 4 of them are used for walking. The remaining two are hunting weapons.	When mating, the female bites the male's head off and consumes his entire body, starting with the head.	In Latin, the insect is known as Mantodea. A Chinese martial art is named after it.
2. ARCHITECTURE Name this structure	Finished in 1930, this building is located on 405 Lexington Avenue, Manhattan, New York City.	Its art deco design has made the structure an iconic component of the New York City skyline.	The skyscraper was the world's highest structure for about a year, until it was beaten by the Empire State Building.	William van Alen designed the pointed structure, whose upper floors are covered in stainless steel.	The 77 storey building has 34 lifts and is named after a major American car manufacturer.
3. LEISURE Name this game	It is one of the oldest known games, dating back to Mesopotamia in 2600 BC	The game can only be played by two people. A certain amount of luck is required, but it is a strategic game.	Each player has 15 identical pieces, which are removed from the game when they reach their home.	Each field of the board is marked by a long thin triangle. The players move in opposite directions.	Players use 2 dice and move their pieces according to the score. In case of a double, the player plays the score twice.

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**PERON'S TREE FROG****Scientific name:** *Litoria peroni***Distribution:** Throughout NSW, southern Qld, northern Vic**Status:** Common and unthreatened today, though this could change rapidly, like has happened to many other frog species.

AN EVERYDAY MIRACLE

Look: it's the everyday miracle that remains fascinating to watch up close, and can still deliver surprises. These *Litoria peroni*, or Peron's Tree Frog, are a common sight around Sydney on patio windows and in drains after heavy rain. Here, in a licensed breeder's tank, two metamorphs go through the final stages of the remarkable transformation from water-breathing, limbless tadpole into four-legged, terrestrial frog.

Once upon a time almost every house in Australia had a tank full of tadpoles slowly growing legs, but new protections and ongoing frog scarcity mean many people haven't watched the process up close. The rear legs grow externally, slowly morphing from foetal stumps, growing powerful muscles, webbed feet, and in the case of *Litoria peroni*, specialised spoon-shaped

toes for climbing.

The front legs don't appear to grow at all, and many casual observers might be surprised to find an animal that had no front legs the night before suddenly has a beautiful set of forelimbs the next morning. In fact, the tadpole grows the front legs under the skin, and pushes them through quite suddenly - if you time it right you can see metamorphs that appear to have three legs, or three legs and an elbow.

Once it has four limbs, the metamorph begins to undergo rapid and dramatic changes over a matter of hours rather than days. Its eyes grow, protrude from the head and develop beautiful colours and patterns. The jaw changes from the tiny nibbling mouth of the tadpole into a wide frog mouth capable of snatching almost any kind of insect. And the skin becomes much more

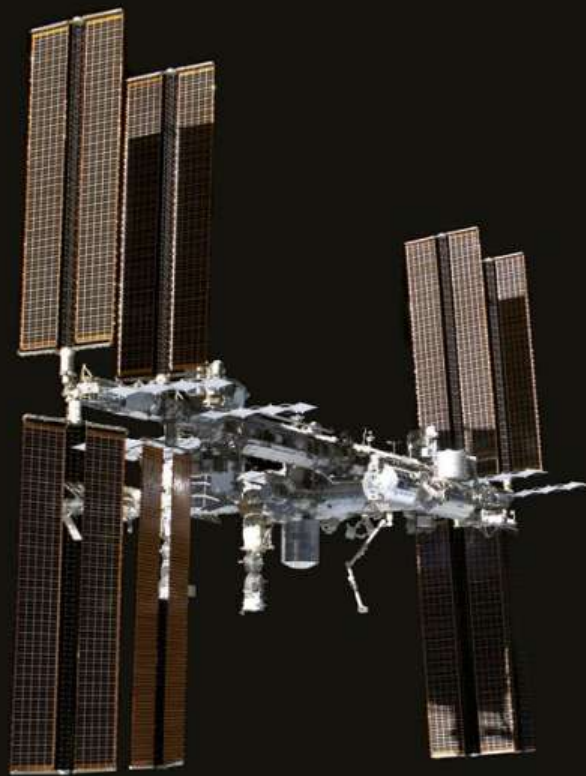
complex, with patterns and texture and of course the all-important ability to allow the animal to survive out of the water.

Finally, the tadpole's primitive gills are replaced by lungs and the metamorph crawls from the water. The tail at this stage is still very prominent, but has lost its delicate membrane. Over the next few days, the frog will absorb the tail, using the raw materials to sustain itself - it won't eat at all during this process.

What must this be like for the frog? The animal's entire body is alive with frantic stem-cell activity, massively rapid cell division, huge changes. Like puberty, times a thousand, and sped up into just a few days.

After months or even a year as a water-dweller, the frog crawls onto damp leaf-litter and, we can only imagine, thinks: "Man, I just had the strangest dream..." 

TRIVIA ANSWERS: 1. Sapphire crystal. 2. The Wedge-tailed Eagle. 3. False. Physical limits mean the landers are too small to see with even the most theoretically powerful optical scopes. 4. Termites. 5. Warrumbungle National Park, NSW. 6. Four. 7. A private crewed spacecraft. 8. Quarks. 9. Wikipedia. 10. Rupert Murdoch. **Trivia Countdown:** Name this insect: Praying mantis. Name this structure: Chrysler Building. Name this Game: Backgammon



THE SKY IS NO LONGER THE LIMIT.

The screens of the Future are available today!

Screen Innovations has worked with NASA to develop a one-of-a-kind, ambient-light-rejecting, zero-gravity screen to be installed in the International Space Station...

Until now, astronauts on the International Space Station communicated with Mission Control and their families back home on tablet-sized 13-inch displays. Now they will have a large roll-out screen from Screen Innovations, together with a laser projector that should last more than 30,000 hours of use – that's a movie a day for more than 40 years.

The criteria for a screen in space were unique, from the obvious need for extreme lightness and easy storage to trickier requirements such as screen rigidity in zero gravity and the ability to reject the bits of food and other detritus that have a habit of floating around zero-gravity environments.

Although the theatre in your home resides in a more-worldly environment with picture quality taking a front row seat it's nice to know that Screen Innovations also delivers the best down-to-earth solution around.



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